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USER'S GUIDE FOR SEALOADS VERSION 1.0: A COMPUTER PROGRAM FOR PREDICTION OF NONLINEAR SHIP MOTIONS, SEALOADS AND PRESSURE DISTRIBUTION IN THE TIME DOMAIN

Wei Qiu & C.C.Hsiung

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A COMPUTER PROGRAM FOR PREDICTION OF NONLINEAR SHIP MOTIONS, SEALOADS AND PRESSURE DISTRIBUTION IN THE TIME DOMAIN

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ABSTRACT

The 3D time-domain computer program SEALOADS version 1.0 calculates the nonlinear response of a ship in severe waves in the time-domain. The output includes ship motions, hydrodynamic pressure distribution, and hull-girder loads. The program written in FORTRAN consists of four independent sub-programs: RAD to compute the response function due to radiated waves; DIF to compute the response function due to diffracted waves; DAMP to compute the roll damping coefficients; and SEALOAD, the main program to compute the ship motions, pressures, and hull-girder loads. This manual describes the installation and operation of SEALOADS version 1.0 on a FreeBSD UNIX system. The structures of input and output data files are described, and example files are illustrated.

RÉSUMÉ

La version 1.0 du programme d'ordinateur temporel 3-D SEALOADS calcule la réponse non linéaire d'un navire pris par de fortes vagues dans le domaine temps. Comme données de sortie, on obtient les mouvements des navires, la distribution de la pression hydrodynamique et les charges de la poutre-coque. Le programme est écrit dans le langage FORTRAN et comprend quatre sous-programmes indépendants : le RAD pour calculer la fonction de réponse due aux vagues rayonnées; le DIF pour calculer la fonction de réponse provoquée par les vagues diffractées; le DAMP pour calculer les coefficients d'amortissement en roulis et le SEALOADS, le programme principal, pour calculer les mouvements des navires, les pressions et les charges de la poutre-coque. Le manuel décrit l'installation et l'utilisation de la version 1.0 du SEALOADS sur un système libre BSD UNIX. La structure des fichiers de données de saisie et des fichiers de données de sortie y est décrite et des exemples de fichiers, illustrés.

User's Guide for SEALOADS version 1: A Computer Program for Prediction of Nonlinear Ship Motions, Sea Loads, and Pressure Distribution in the Time Domain

by

W. Qiu and C.C. Hsiung

EXECUTIVE SUMMARY

Introduction

An integral part of DREA's effort to ensure safety against the structural failure of Canadian Forces ships, the FORTRAN program SEALOADS version 1.0 calculates the nonlinear response of a ship to severe ocean waves. Nonlinear response of the ship to large-amplitude waves must be properly accounted for in assessing the ability of ship to withstand a specified sea state with an acceptable risk of failure. The computations in SEALOADS are done in three-dimensional space in the time domain. As well as ship motions, the output includes the hydrodynamic pressure distribution on the wetted hull surface and bending moments and shear forces on the hull, which are necessary input for finite-element structural analysis. SEALOADS consists of four independent sub-programs: RAD to compute the response function due to radiated waves; DIF to compute the response function due to diffracted waves; DAMP to compute the roll damping coefficients; and SEALOAD, the main program to compute the ship motions, pressures, and hull-girder loads. This manual describes the installation and operation of SEALOADS version 1.0 on a FreeBSD UNIX system. The structures of input and output data files are described, and example files are illustrated.

Results

The results show that the computer program SEALOADS provides a practical means for calculating large-amplitude nonlinear loads that are beyond the realm of the conventional linear frequency-domain computer programs.

Significance

The extreme loads are a key factor to be considered in the hull structural analysis, but because they occur very rarely, the characteristics of these loads are still poorly understood. SEALOADS serves as a practical analytical tool for examining them.

Future Plans

Future plans include extensive code validation studies, refinement of the algorithms and/or theoretical models to improve the robustness, development of a more advanced method of calculating bow-flare impact force, application of the non-uniform rational B-splines (NURBS) for representing the ship hull surface. As well, development of a comprehensive analysis tool for the realistic hydroelastic response of the ship girder based on the framework of SEALOADS is envisaged.

Guide d'utilisation de la version 1.0 de SEALOADS, programme d'ordinateur servant à prévoir les mouvements non linéaires des navires, les charges marines et la distribution de pression dans le domaine temps

W. Qiu et C.C. Hsiung

SOMMAIRE

Introduction

Partie intégrante des efforts du CRDA en vue de garantir la sécurité contre les défaillances structurales des navires des Forces canadiennes, le programme en FORTRAN SEALOADS, version 1.0, calcule la réponse non linéaire d'un navire aux vagues d'un océan agité. Il est essentiel de tenir correctement compte de la réponse non linéaire du navire aux vagues de forte amplitude afin d'évaluer la capacité du navire à supporter un état spécifié d'agitation de la mer avec des risques de défaillance acceptables. Les calculs de SEALOADS s'effectuent dans l'espace tridimensionnel et dans le domaine temps. Outre les mouvements des navires, la sortie comprend la distribution de la pression hydrodynamique sur la surface mouillée de la coque ainsi que les moments de flexion et les forces de cisaillement sur la coque, qui sont nécessaires à l'analyse structurale par éléments finis. SEALOADS se compose de quatre sous-programmes indépendants : RAD qui calcule la fonction de réponse due aux ondes rayonnées; DIF qui calcule la fonction de réponse due aux ondes diffractées; DAMP qui calcule les coefficients d'amortissement du roulis; et SEALOAD, le programme principal qui calcule les mouvements du navire, les pressions et les charges de la poutre-coque. Ce guide décrit l'installation et l'utilisation de SEALOADS, version 1.0, sur un système UNIX FreeBSD. La structure des fichiers de données d'entrée et de sortie est décrite, et des fichiers sont donnés en exemple.

Résultats

Les résultats démontrent que le programme d'ordinateur SEALOADS constitue un moyen pratique de calculer les charges non linéaires de forte amplitude que n'englobent pas les programmes d'ordinateur classiques à domaine fréquence linéaire.

Portée

Les charges extrêmes constituent un facteur clé pour l'analyse structurale des coques, mais leur très faible occurrence n'a pas encore permis d'en bien comprendre les caractéristiques. SEALOADS représente un outil analytique pratique pour leur examen.

Plans pour l'avenir

On prévoit dans l'avenir effectuer des études poussées de validation de code, améliorer les algorithmes et/ou modèles théoriques afin d'accroître la robustesse, élaborer une méthode perfectionnée permettant de calculer la force de l'impact sur la carène avant et appliquer des courbes B-Spline rationnelles non uniformes (NURBS) pour représenter la surface de la coque des navires. On envisage également la mise au point d'un outil d'analyse global qui puisse déterminer la réponse hydroélastique réaliste de la poutre-navire dans le cadre établi par SEALOADS.

User's Guide for SEALOADS Version 1.0

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2. PART I – PROGRAM: RAD

3. PART II – PROGRAM: DIF

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OVERVIEW OF SEALOADS VERSION 1.0

The "SEALOADS Version 1.0" program was developed at the Centre for Marine Vessel Development and Research (CMVDR), DalTech, Dalhousie University. The main purpose of the program is to predict the nonlinear ship motions, hydrodynamic pressure distribution over the hull and sea loads in the time-domain.

This manual is to be used to operate SEALOADS Version 1.0.

The major capabilities of SEALOADS Version 1.0 include:

- Computation of the ship motions, hydrodynamic pressure distribution and sea loads in regular waves.
- Computation of motions, hydrodynamic pressure distribution and sea loads in irregular waves defined by significant wave height and spectral period. Short-term statistics are included.
- Computation of slamming forces.

The program suite consists of four independent programs:

(1). RAD - program to compute the response function due to radiated waves,

(2). DIF - program to compute the response function due to diffracted waves,

(3). DAMP – program to compute the roll damping coefficients,

(4). SEALOAD - kernel program to compute the ship motions, pressures and sea loads.

The four programs should be run in sequence so that the output generated by the preceding programs is used as input to subsequent programs. The running sequence is shown in Figure 1.

This manual consists of five parts to provide necessary information for operation of four modules of SEALOADS version 1.0. In addition to the description in details of input and output formats, examples of input and output files are attached in Appendices.

Part I is concerned with the installation of all SEALOADS modules.

Part II gives detailed information on the input and output of the RAD module. Examples of input and output files are also given to aid the user.

Part III provides the detailed information on the input and output of the DIF module. Examples of files are provided as well.

PART IV presents the information on the input/output of the DAMP module. Examples of files are provided as well.

Part V gives the information of the input and output of main program – SEALOAD. Examples of files are attached in Appendices.

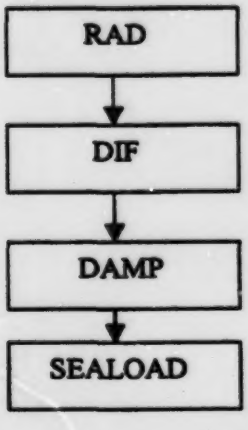

Figure 1. Flow chart of running sequence for SEALOADS Version 1.0

PART I INSTALLATION OF SEALOADS VERSION 1.0

SEALOADS VERSION 1.0 – PART I

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1 INTRODUCTION

This part of the User's Manual is associated with the installation and execution of SEALOADS.

Currently, the source code and database of the program suite are supplied and can be installed on the hard disk of a computer operating with a UNIX or LINUX system only and using the FORTRAN77 compiler. A computer with a **minimum of 256Mbytes of RAM** is recommended. In the future, a version for Windows will be implemented.

2 DIRECTORY STRUCTURE

The directory structure is given in Figure 1. The contents of each directory are described as follows:

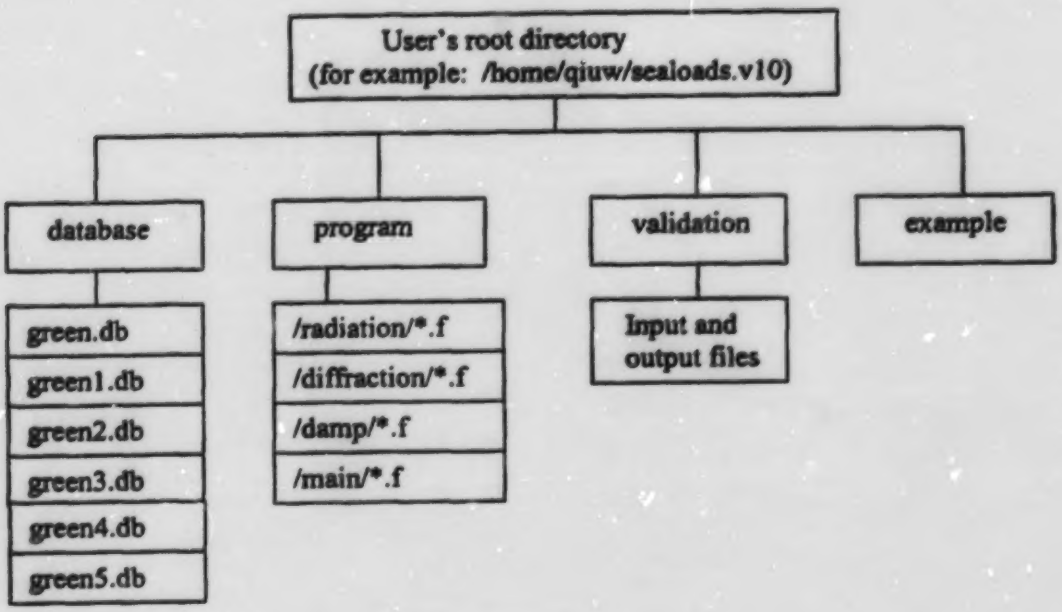

Figure 1. Directory structure

/sealoads.v10	main SEALOADS directory.
/sealoads.v10/database	common data for the computation of the time-domain Green function.
/sealoads.v10/program/radiation	source codes and Makefile. After compiling, the corresponding executable file – RAD will be generated in this directory.
/sealoads.v10/program/diffraction	source codes and Makefile. After compiling, the corresponding executable file – DIF will be generated in this directory.

/sealoads.v10/program/damp	source codes and Makefile. After compiling, the corresponding executable file – DAMP will be generated in this directory.
/sealoads.v10/program/main	source codes and Makefile. After compiling, the corresponding executable file – SEALOAD will be generated in this directory.
/sealoads.v10/validation	input files prepared by the user. After running the four programs, all output files are in this directory.
/sealoads.v10/example	all examples of files as provided in the Appendices of this User's Guide.

2.1 SOURCE CODE FILES FOR THE RADIATION PART

The following files are contained in the directory, /Seaload.v10/program/radiation,

rad.f	main program for the radiation part,
doubbody.f	compute double-body flow,
gauss.f	compute Gaussian points,
geometry.f	compute ship's hydrostatics,
greent.f	carry out integration of the time-domain Green function,
input.f	read input files,
interp.f	program for interpolations.
phit.f	solve potentials in the time domain,
potent.f	solve time-independent potentials,
retarf.f	compute response function of total forces,
retarp.f	compute response function of pressure on each panel,
solver.f	solve linear equations.

2.2 SOURCE CODE FILES FOR THE DIFFRACTION PART

The following files are contained in the directory, /Seaload.v10/program/diffraction,

dif.f	main program for the diffraction part,
doubbody.f	compute double-body flow,
gauss.f	compute Gaussian points,
geometry.f	contains subroutines related to the geometry computation,
greent.f	carry out integration of the time-domain Green function,
input.f	read input files,
interp.f	program for interpolations.
phi.f	solve potentials in the time domain,
potent.f	solve time-independent potentials,
retarf.f	compute response function of total forces,
retarp.f	compute response function of pressure on each panel,
solver.f	solve the linear equations.

2.3 SOURCE CODE FILES FOR THE SEALOAD PART

The following files are contained in the directory, /Seaload.v10/program/main,

damp.f	compute the damping forces,
euler.f	first-order Euler solver
fft.f	carry out Fast Fourier Transform,
force.f	compute exciting forces,
geometry.f	contains subroutines related to the geometry computation,
initial.f	set up initial conditions,

input.f	read input files,
interpolate.f	contains subroutines related to interpolations,
kutta.f	the Runge-Kutta scheme,
main.f	main program for SEALOAD part,
otherf.f	compute forces from rudder, maneuvering, etc.
output.f	give output of computational results
pressure.f	compute pressure distribution,
seaload.f	compute sea loads acting on a cross section,
slam.f	compute slamming forces,
solver.f	solve equations of ship motion by the Runge-Kutta scheme,
statics.f	carry out statistical analysis of ship motions, pressure and sea loads,
transform.f	carry out transformations between different coordinate systems,
wave.f	generate the required waves.

3 INSTALLATION

The procedure of installation is as follows:

STEP A. Make directories as described in Section 2.

STEP B. Copy all files into corresponding directories using *ftp* or *cp* command.

STEP C. Get into the directory, /sealoads.v10/program, and run the following commands to generate the executable files:

- Enter /sealoads.v10/radiation and run *make*; and the executable file RAD will be generated.
- Enter /sealoads.v10/diffraction and run *make*; and the executable file DIF will be generated.
- Enter /sealoads.v10/damp and run *make*; and the executable file DAMP will be generated.
- Enter /sealoads.v10/main and run *make*; and the executable file SEALOAD will be generated.

STEP D. Return to the root directory of the user and edit the file *.cshrc* as follows:

- Set the path to /sealoads.v10/program/radiation, /sealoads.v10/program/diffraction, /sealoads.v10/program/damp, and /sealoads.v10/program/main.
- Run *source .cshrc*

STEP E. The user will run the four programs in the described sequence at the directory of /sealoads.v10/validation, where a file named *sealoads.path* must be provided to set up the path to the database. An example of *sealoads.path* is as follows,

'/home/qiuw/sealoads.v10/database'

4 TROUBLE SHOOTING

The following problems *may* occur when using SEALOADS,

- Unable to run RAD, DIF, DAMP and SEALOAD

  This may occur because the path is not correctly set up. We suggested that the user check the file *.cshrc*, and re-run *source .cshrc*.

PART II PROGRAM: RAD

SEALOADS V1.0 – PART II

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1 INTRODUCTION

This chapter is associated with RAD (RADiation) which is a module in the SEALOADS package. The RAD module is responsible for computing the response function of radiated waves and calculating ship hydrostatics for programs DIF, DAMP and SEALOAD.

The main text of this chapter describes input/output files, their format and record.

A brief description of information relevant to incident waves is given in Appendix I. Examples of input/output files for a Canadian Patrol Frigate (CPF) are presented in Appendices II to VIII.

2 INPUT AND OUTPUT FILES

2.1 INPUT FILES

To run RAD, the user needs to provide with the following input files:

1. <filename>.ctr — main input file contains:
   - Principal ship dimensions and hydrostatics
   - Physical constants
   - Control indices for computing options
   - Time step data
   - Initial conditions
   - Incident wave information.
2. <filename>.msh — contains information on nodes and panels under the waterline
3. <filename>.mass — contains mass distribution of the ship

where <filename> is a suitable name string up to 25 characteristics in length.

Note that RAD, DIF, DAMP and SEALOAD share the same input file: <filename>.ctr and <filename>.msh. The format and description of these two files are given in Sections 3 and 4. Examples of input files are presented in Appendices II, III and IV.

2.2 OUTPUT FILES

Upon successful program execution, the following output files will be produced:

1. <filename>.chk — Contains a display of information on ship hydrostatics and panel normals.

2.	<filename>.data	Contains principal dimensions, hydrostatics and weight distribution.
3.	<filename>.adms	Contains matrices of added mass, damping and restoring forces.
4.	<filename>.geom	Contains the panel geometry information for the computation of viscous roll damping.
5.	<filename>.kijf	Contains response functions of total forces due to radiated waves
6.	<filename>.kijfx	Contains response functions of sea loads acting on a given cross section due to radiated waves
7.	<filename>.kijp	Contains response function of pressure at each panel centroid.

The format and description of output files are given in Section 5 and examples of four output files are presented in Appendices V to VIII.

The organization of input/output files is shown in Figure 1.

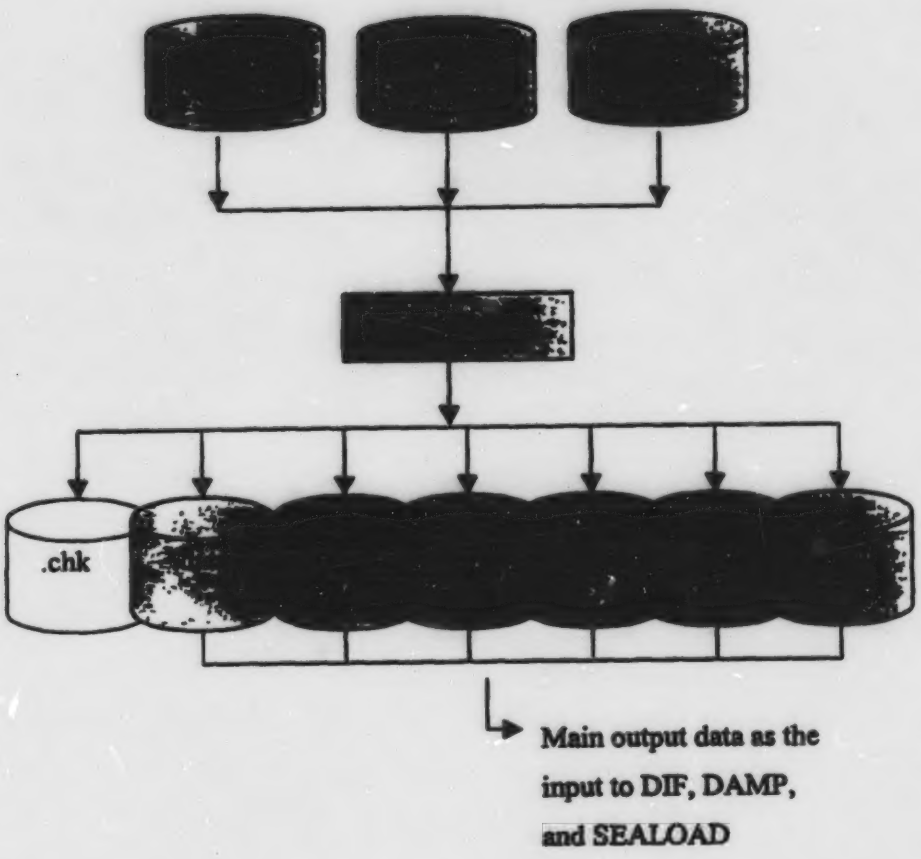


Figure 2.1 Organization of input/output files for program RAD

3 FORMAT OF INPUT FILES

The following is the format of the input files: <filename>.ctr, <filename>.mass and <filename>.msh. The definitions of records in these files are given in Section 4. Comment lines can be introduced by making '#' as the first character of the line. The program does not differentiate upper or lower case characters.

3.1 FORMAT OF <FILENAME>.CTR

```
# Job title, ship name, user's name and data

&names
jobtitle
shipname
user
data
/end{names}

# Principal dimensions

&shipdata
sl
sb
sd
cb
fn
xg
yg
zg
rxx
ryy
```

rzz
volume
mass
ixx
iyy
izz
/end{shipdata}

Water density

&waterdensity
waterden
/end{waterdensity}

Control indices for options

&controls
presctr
sealoadctr
motionctr
initctr
slammctr
/end{controls}

Damping control

&dampcontrol
dampmodel
/end{dampcontrol}

The cross-section for sea loads computation

&xsection
xcx
/end{xsection}

 # Time step for simulation

&timedata
dt0
nretar0
nretar
step
numstep
/end{timedata}

 # Non-impulsive function coefficient

&impulsecoeff
alfabar
/end{impulsecoeff}

 # Initial conditions

&init_conditions
motion_init(1), motion_init(2), …, motion_init(6)
vel_init(1), vel_init(2), …, vel_init(6)
acc_init(1), acc_init(2), …, acc_init(6)
/end{init_conditions}

 # Control data for input waves

```
&waves
wavetype
beta
/end{waves}

# Parameters for regular waves

&regularwave
wamp
wfreq
wphase
/end{regularwave}

# Two parameter wave spectra – ISSC, JOHSWAP and Bretschneider spectra

&twospectrum
hs
tp
/end{twospectrum}

# Parameters for Ochi-Hubble wave spectrum

&OchiHubble
hs1
tp1
lambda1
hs2
tp2
lambda2
/end{OchiHubble}
```

```
# Measured spectrum data

&measurespectrum
nspec
specfreq(1), specfreq(2), … specfreq(nspec-1), specfreq(nspec)
spec(1), spec(2), …, spec(nspec-1), spec(nspec)
/end{measurespectrum}

# Parameters for Stokes waves

&stokeswave
wdepth
stoke_amp
stoke_freq
stoke_phase
/end{stokeswave}

# Range of frequencies

&spectrumrange
numregular
lowfreq
upperfreq
/end{spectrumrange}
```

3.2 FORMAT OF <FILENAME>.MSH

nodenum, npanel
1, x(1), y(1), z(1)
2, x(2), y(2), z(2)
…, …, …, …
nodenum-1, x(nodenum-1), y(nodenum-1), z(nodenum-1)
nodenum, x(nodenum), y(nodenum), z(nodenum)
1, nodes(1,1), nodes(2,1), nodes(3,1), nodes(4,1)
2, nodes(1,2), nodes(2,2), nodes(3,2), nodes(4,2)
…, …, …, …, …
npanel-1, nodes(1,npanel-1), nodes(2,npanel-1), nodes(3,npanel-1), nodes(4,npanel-1)
npanel, nodes(1,npanel), nodes(2,npanel), nodes(3,npanel), nodes(4,npanel)

3.3 FORMAT OF <FILENAME>.MASS

nummass

dm(1)	xm(1)	ym(1)	zm(1)
dm(2)	xm(2)	ym(2)	zm(2)
…	…	…	…
dm(nummass-1)	xm(nummass-1)	ym(nummass-1)	zm(nummass-1)
dm(nummass)	xm(nummass)	ym(nummass)	zm(nummass)

4 DESCRIPTION OF INPUT FILES

4.1 DESCRIPTION OF <FILENAME>.CTR

4.1.1 NAMES RECORDS

jobtitle - can be any set of characters (80 maximum) between single quotes (no embedded quotes)

shipname - can be any set of characters (50 maximum) between single quotes (no embedded quotes)

user - user's name, can be any set of characters (15 maximum) between single quotes (no embedded quotes)

date - date or time, can be any set of characters (15 maximum) between single quotes (no embedded quotes)

4.1.2 SHIPDATA RECORDS

If any of these records are omitted then the values of records are obtained from the mesh geometry calculation and/or the weight distribution. All quantities, except where stated, are measured with respect to a right-handed co-ordinate system o,x,y,z, (Figure 4.1, see Figure 4.2 for the three coordinate systems used in SEALOADS) fixed on the ship, with origin o, as the intersection of the centerline and the design waterline at the midship section, the x,-axis positive forward, the y,-axis positive towards the port and the z,-axis positive upwards.

sl - length between perpendiculars, *meter*. **This record must not be omitted.**

sb - maximum beam, *meter*. **This record must not be omitted.**

sd - mean draft, *meter*. **This record must not be omitted.**

cb - block coefficient. **This record must not be omitted.**

fn - Froude number. **This record must not be omitted.**

xg,yg,zg - coordinates of the center of gravity (CG), *meter*. If this record is omitted the values are obtained from the weight distribution. If the weight distribution is not available then the CG will be placed on the center of buoyancy which is computed based on the mesh geometry.

rxx - radius of gyration for roll about CG, *meter*. If this record is omitted, rxx=0.35sb.

ryy - radius of gyration for pitch about CG, *meter*. If this record is omitted, ryy=0.25sl.

rzz - radius of gyration for yaw about CG, *meter*. If this record is omitted, rzz=0.25sl.

volume - volume of displacement, m^3. If this record is omitted, it will be computed from the input mesh geometry.

mass - total mass of ship, *kg*. If this record is omitted the value will be obtained from the weight distribution. If the weight distribution is not available then the total mass will be set as the product of water density and volume of displacement.

ixx, iyy, izz - moments of inertia about CG. If these records are omitted the values will be obtained from the input weight distribution. If the weight distribution file is not available, then $ixx = mass \times R_{xx}^2$, $iyy = mass \times R_{yy}^2$ and $izz = mass \times R_{zz}^2$

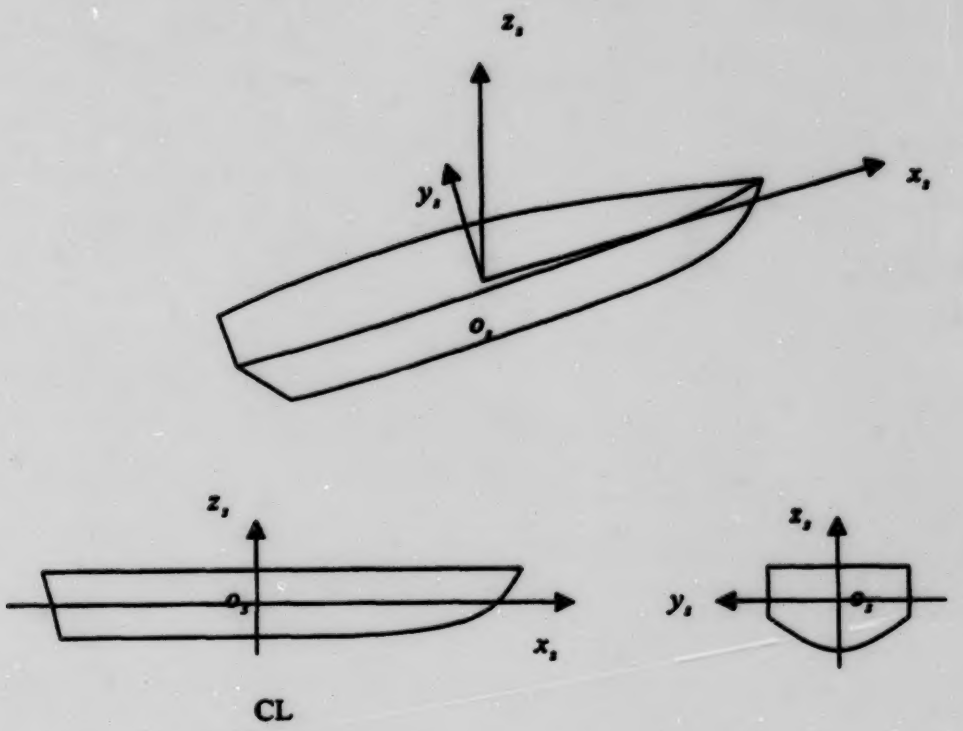
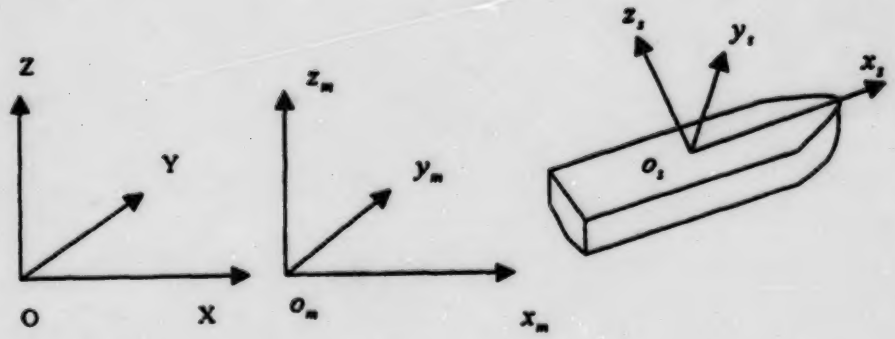


Figure 4.1 Coordinate system fixed on the ship



O-XYZ: the space-fixed coordinate system

$o_m - x_m y_m z_m$: the steady-moving coordinate system

$o_s - x_s y_s z_s$. the ship-fixed coordinate system

Figure 4.2 Coordinate systems

4.1.3 WATERDENSITY RECORD

waterden - density of water, kg/m^3. If this record is omitted then it is set as 1024.0 kg/m^3.

4.1.4 CONTROLS RECORDS

presctr	= 0, pressure distribution won't be computed.
	= 1, pressure distribution will be computed.
sealoadctr	= 0, sea loads acting on a specific cross-section won't be computed.
	=1, sea loads acting on a specific cross-section will be computed.
motionctr	=0, only heave, roll, and pitch motions will be computed.
	=1, six degree-of-freedom motions will be computed.
initctr	=0, ship starts motion at its rest position.
	=1, ship starts motion at a given initial condition.
slammctr	=0, slamming forces won't be computed.
	=1, slamming forces will be computed.

The above records cannot be omitted.

4.1.5 OUTPUTCONTROL RECORD

This record contains the following options for output:

outwave	= 0, history of wave elevation at the origin of the steady moving coordinate system will be given as output.
	= 1, history of wave elevation at the origin of the space-fixed coordinate system will be given as output.

Note that coordinate systems are shown in Figure 4.2.

4.1.6 DAMPCONTROL RECORD

The user can select one of five damping models to calculate the viscous roll damping coefficients. The damping models are described in Appendix II.

dampmodel =0, empirical formulae will be used to calculate the damping coefficients α_1 and α_2.

=1, damping model $\alpha_1\dot{\phi}+\alpha_2|\phi|\dot{\phi}$ is used.

=2, damping model $\alpha_1\dot{\phi}+\alpha_2|\phi|^2\dot{\phi}$ is used.

=3, damping model $\alpha_1\dot{\phi}+\alpha_2\dot{\phi}^3$ is used.

=4, damping model $\alpha_1\dot{\phi}+\alpha_2\dot{\phi}|\dot{\phi}|$ is used.

4.1.7 XSECTION RECORD

xcx - location of the cross-section where sea loads will be computed (see Figure 4.3). xcx=0.0 amidship, xcx=sl/2.0 at FP and xcx=-sl/2.0 at AP.

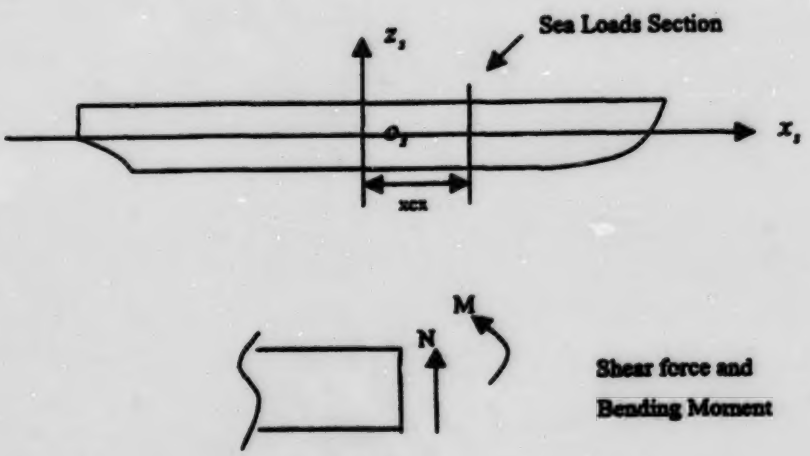


Figure 4.3 Definitions of sea loads section and sea loads

4.1.8 TIMEDATA RECORDS

dt0 - time step used in computations for the response functions in RAD and DIF. The recommended value is in the range of 0.25 to 0.5s for a full-scale ship.

nretar0 - number of time steps used in computations of response functions in RAD and DIF. The maximum value is 200.

nretar - number of time steps used in the output of response functions in RAD and DIF. The suggested value is nretar=6*nretar0.

step - time step used in the main program, SEALOAD for simulation. If this record is omitted, then step=dt0/6.

numstep - number of time steps used in SEALOAD. The maximum value is 50,000.

4.1.9 IMPULSECOEFF RECORD

alfabar - coefficient for the non-impulsive function, $\dot{\xi}_j(t) = \sqrt{\frac{\overline{\alpha}}{\pi}} e^{-\overline{\alpha} t^2}$. If this record is omitted, $\overline{\alpha} = 0.1$. The recommended value is in the range of 0.05 to 0.25.

4.1.10 INIT_CONDITIONS RECORDS

If initctr=0, these records can be omitted.

motion_init - initial motions. motion_init(1), motion_init(2), motion_init(3), motion_init(4), motino_init(5) and motion_init(6) represent the initial surge, sway, heave, roll, pitch and yaw motions, respectively. Note that these motions are in the steady-moving coordinate system.

vel_init - initial velocities. vel_init(1), vel_init(2), ..., vel_init(5) and vel_init(6) are the six-degree-of-freedom velocities in the ship-fixed coordinate system.

acc_init - initial accelerations in the ship-fixed coordinate system. acc_init(1), acc_init(2), ..., and acc_init(6) are the six-degree-of-freedom accelerations in the ship-fixed system.

Note that the translational motion displacements are all in *meters* and the angular displacements are in *radians*.

4.1.11 WAVES RECORDS

wavetype - types of incident waves.
=0, regular waves
=1, ISSC spectrum (two parameters)
=2, JONSWAP spectrum (two parameters)
=3, Bretschneider spectrum (two parameters)
=4, Ochi-Hubble six parametric spectrum
=5, measured spectrum
=6, second-order Stokes waves

beta - ship heading in *degree*. 0° is following waves, 90° is starboard beam waves, and 180° is head waves (see Figure 4.4).

Descriptions of regular waves, various wave spectra and second-order Stokes waves are given in Appendix I.

4.1.12 REGULARWAVE RECORDS

If wavetype ≠ 0, the following records can be omitted.

wamp - wave amplitude, *meter*.

wfreq - wave frequency, *rad/sec.*
wphase - the initial phase angle, *degree.*

4.1.13 TWOSPECTRUM RECORDS

If wavetype ≠ 1, 2, or 3, the following records can be omitted.

hs - significant wave height, *meter.*
tp - peak wave period, *second.*

4.1.14 OCHIHUBBLE RECORDS

If wavetpye ≠ 4, the following records can be omitted.

hs1, hs2 - significant wave heights, *meter,* for components 1 and 2.
tp1, tp2 - peak wave periods, *second,* for components 1 and 2.
lambda1 - spectra shape parameter for component 1.
lambda2 - spectra shape parameter for component 2.

4.1.15 MEASURESPECTRUM RECORDS

If wavetpye ≠ 5, the following records can be omitted.

nspec - number of measured wave spectra values.
specfreq (i) - wave frequency, *rad/s*, i=1,2, ..., nspec.
spec (i) - measured spectra value, $m^2/(rad/s)$, i=1,2, ..., nspec.

4.1.16 STOKESWAVE RECORDS

If wavetpye ≠ 6, the following records can be omitted.

wdepth - depth of water, *meter*.
stoke_amp - wave amplitude, *meter*.
stoke_freq - wave frequency, *rad/sec*.
stoke_phase - initial phase angle, *degree*.

4.1.17 SPECTRUMRANGE RECORDS

If wavetype=0 or 6, the following records can be omitted.

numregular - number of regular wave components in the irregular waves.
lowfreq - lower end of frequency in the spectrum, *rad/sec*.
upperfreq - upper limit of frequency in the spectrum, *rad/sec*.

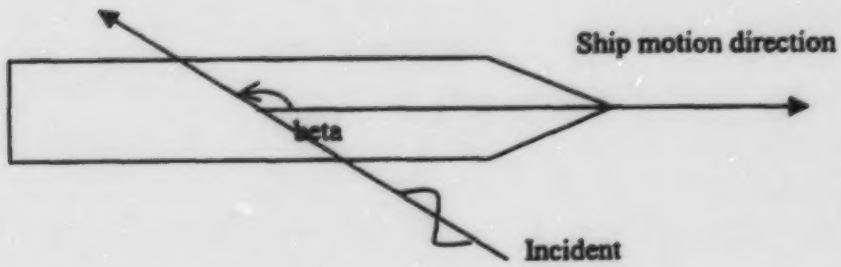


Figure 4.4 Definition of wave heading

4.2 DESCRIPTION OF <FILENAME>.MSH

The underwater surface of the port side of hull is discretized into a number of quadrilateral panels. This file contains the information on nodes and panel connectivity.

RECORD 1 – NODENUM, NPANEL

nodenum	- number of nodes on the port side of hull (500 maximum)
npanel	- number of panels on the port side of hull (260 maximum)

RECORD 2 – NO(I), X(I), Y(I), Z(I), I=1, 2, ..., NODENUM

NO(I)	- number identifying the *i*th node point
X(I), Y(I), Z(I)	- coordinates of the *i*th node point. The coordinates are with respect to a right-handed coordinate system with the origin at the intersection of centerline and waterline at the midship section (see Figure 4.1).

RECORD 3 – NO(I), PANEL(1,I), PANEL(2,I), PANEL(3,I), PANEL(4,I), I = 1, 2, ..., NPANEL

NO(I)	- number identifying the *i*th panel.
PANEL(1,I)	- first node of the *i*th panel.
PANEL(2,I)	- second node of the *i*th panel.
PANEL(3,I)	- third node of the *i*th panel.
PANEL(4,I)	- fourth node of the *i*th panel.

The input nodes in each panel must be entered in such a sequence that the normal direction of the panel points to the inside of the hull as if the panel is viewed from inside of the hull (see Figure 4.5).

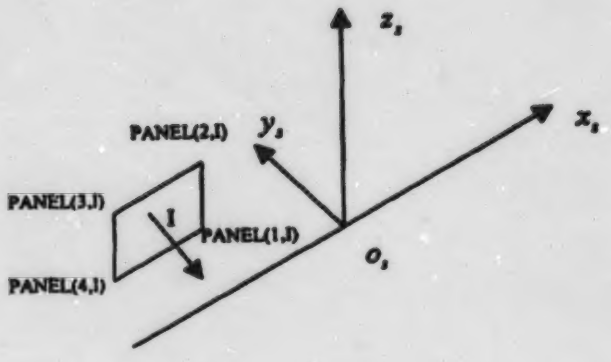


Figure 4.5 Panel connectivity

4.3 FORMAT OF <FILENAME>.MASS

Computation of sea loads requires an accurate description of ship weight distribution. It is assumed that the weight is uniformly distributed between given segments. The segment can be between any X_1 and X_2 entered by the user (see Figure 4.6) and segments need not necessarily be in equal length. Note that if a cross section, *xcx*, where sea loads are to be computed, is located in a segment (X_1, X_2), then the segment must be separated into two segments (X_1, xcx) and $xcx, X_2)$.

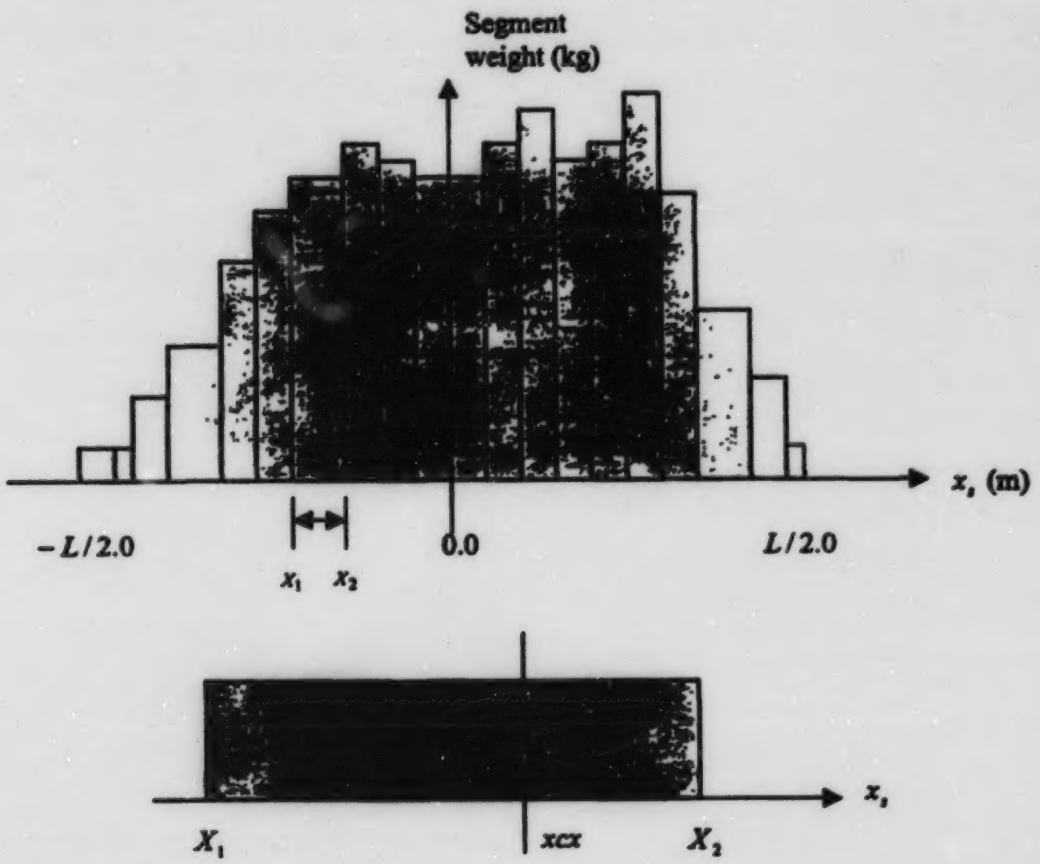


Figure 4.6 Weight distribution

4.3.1 NUMMASS RECORD

NUMMASS	number of weight segments (100 maximum)

4.3.2 MASS SEGMENT RECORD

DM(1)	XDM(1)	YDM(1)	ZDM(1)
DM(2)	XDM(2)	YDM(2)	ZDM(2)
...	...	...	...
DM(nummass-1)	XDM(nummass-1)	YDM(nummass-1)	ZDM(nummass-1)
DM(nummass)	XDM(nummass)	YDM(nummass)	ZDM(nummass)

DM(I)	weight of segment *i*, *kg*.
XDM(I)	x-coordinate, the center of gravity of segment *i*, *m*
YDM(I)	y-coordinate, the center of gravity of segment *i*, *m*
ZDM(I)	z-coordinate, the center of gravity of segment *i*, *m*

NOTE: The coordinates are given with respect to a right-handed coordinate system, with the origin at the intersection of the centerline and the calm waterline at the midship section.

5 DESCRIPTION OF OUTPUT FILES

The following is a brief description of the records in the output files <filename>.chk, <filename>.data, <filename>.adms, <filename>.geom, <filename>.kijf, <filename>.kijfx, and <filename>.kijp.

5.1 <FILENAME>.CHK RECORDS

This file contains the following information:

- The title page
- Summary of input hydrostatics
- Summary of calculated hydrostatics
- Normal of each panel

The format of this file is given as below:

Record	Description
1	Job title
2	Ship name
3	User's name
4	Date
5	Lpp
6	Beam
7	Draft
8	Cb
9	Froude number
10	Center of gravity (xg, yg and zg)
11	rxx

12	ryy
13	rzz
14	ixx
15	iyy
16	izz
17	Volume of displacement
18	mass
19	Computed center of gravity (xg, yg and zg)
20	Computed gyradius – rxx
21	Computed ryy
22	Computed rzz
23	Computed moment of inertia – ixx
24	Computed iyy
25	Computed izz
26	Computed volume of displacement from x-direction, volume-x
27	Computed volume-y
28	Computed volume-z
29	Computed total mass
30	Computed area of wetted surface
31	Computed area of waterplane
32	Computed center of floatation, (xb,yb,zb)
33	Normal of each panel

5.2 <FILENAME>.DATA

This file contains the principal dimensions, hydrostatics and mass distributions. This file is the input file for programs DIF, DAMP, SEALOAD and SEAPOST.

Record	Description
1	sl, sb, sd, cb, fn, xg, yg, zg, rxx, ryy, rzz,

	ushp, volume, mass, ixx, iyy, izz
2	nummass, dm, xdm, ydm, zdm, fxg, fyg, fzg, fmass, frxx,fryy

In record (1), the symbol, Ushp, is the ship speed in *meter/second*. In record (2), symbols, fxg,fyg,fzg, are the center of gravity of the fore-body between the sea loads section *xcx* considered and FP; fmass is the mass of the fore-body; frxx and fryy are the radii of gyration about the x and y axis, respectively.

5.3 <FILENAME>.ADMS

This file contains the information on added mass, restoring force and damping coefficients. The file is the input file to SEALOAD.

Record	Description
1	Added mass matrix (6x6)
2	Restoring force coefficient matrix (6x6)
3	Damping coefficient matrix (6x6)
4	Added mass matrix of the fore-body which is from the section *xcx* to FP
5	Restoring force coefficient matrix of the fore-body
6	Damping coefficient matrix of the fore-body
7	Added mass matrix of the aft-body which is the portion from AP to the section *xcx*
8	Restoring force coefficient matrix of the aft-body
9	Damping coefficient matrix of the aft-body

4.4 <FILENAME>.GEOM

This file contains the panel geometry information, which can be used for estimating viscous roll damping coefficients in Part IV. The format is as follows:

cy(i) cz(i) area(i)	coordinates of the centroid of panel *i* and area of panel *i* (i=1,2, …, num).
ny(i) nz(i)	the normal directions of panel *i* along y- and z-axis (i=1,2, …, num)

where num is the number of panels.

5.5 <FILENAME>.KIJF

This file contains the response function of the total force acting on the ship body. It is an input file to SEALOAD.

Time	Response function
t(1)	Response function K_{ij} at time $t = 0$
t(2)	Response function K_{ij} at time $t = step$
t(3)	Response function K_{ij} at time $t = 2 \times step$
…	…
t(nretar-1)	Response function K_{ij} at time $t = (nretar - 1) \times step$
t(nretar)	Response function K_{ij} at time $t = nretar \times step$

5.6 <FILENAME>.KIJFX

This file contains the response functions of sea loads acting on the fore-body. It is an input file to SEALOAD.

Time	Response function
t(1)	Response function K_{ij}^{X} (6x6) at time 0
t(2)	Response function K_{ij}^{X} at time $t = step$
t(3)	Response function K_{ij}^{X} at time $t = 2 \times step$
...	...
t(nretar-1)	Response function K_{ij}^{X} at time $t = (nretar - 1) \times step$
t(nretar)	Response function K_{ij}^{X} at time $t = nretar \times step$

5.7 <FILENAME>.KIJP

This file contains the response functions of pressure on each panel. It is an input file to SEALOAD, and is used for pressure distribution computation. If Presctr=0, this file won't be produced.

Time	Response function
t(1)	Response function K_{ij}^{P} ($6 \times npanel$) at time $t = 0$
	Mode 1: K_{ij}^{P} (1,2,...,npanel)
	Mode 2: K_{ij}^{P} (1,2,...,npanel)
	... ...
	Mode 5: K_{ij}^{P} (1,2,...,npanel)
	Mode 6: K_{ij}^{P} (1,2,...,npanel)
t(2)	Response function K_{ij}^{P} at time $t = step$
t(3)	Response function K_{ij}^{P} at time $t = 2 \times step$
...	...

t(nretar-1)	Response function K_v^p at time $t = (nretar - 1) \times step$
t(nretar)	Response function K_v^p at time $t = nretar \times step$

REFERENCES

[1] ITTC Seakeeping Committee Report, in *15th International Towing Tank Conference* (The Hague, September 1978), Vol. 1, pp. 55-114.

[2] McTaggart, K., "SHIPMO7, An updated strip theory program for predicting ship motions and sea loads in waves", DREA Technical Memorandum 96/243, March 1997.

[3] Ochi, M.K. and Hubble, E.N., "Six-parameter wave spectra", *in 15th Coastal Engineering Conference* (Honolulu, 1976), Vol. 1, pp.301-328.

[4] Sarpkaya, T. and Isaacson, M., Mechanics of wave forces on offshore structures, Van Nostrand Reinhold Company, New York, 1981, pp. 174-175.

[5] Schmitke, R.T., "Ship sway, roll, and yaw motions in oblique seas", Transactoin SNAME, Vol. 86, 1978, pp. 26-46.

APPENDIX I WAVE SPECTRA, REGULAR WAVES AND STOKES WAVES

I.1 ISSC WAVE SPECTRUM

The ISSC spectrum [1,2] is expressed as follows:

$$S(\omega) = \frac{173 H_S^2}{T_1^4 \omega^5} e^{-\frac{691}{T_1^4 \omega^4}} \tag{I-1}$$

where $S(\omega)$ is the spectral density function, H_S is the significant wave height, ω is the wave frequency, T_1 corresponds to the energy averaged frequency using the following relationship for a fully developed sea:

$$T_1 = 0.773 T_p \tag{I-2}$$

$$T_1 = 2\pi \frac{\int_0^\infty S(\omega) d\omega}{\int_0^\infty \omega S(\omega) d\omega} \tag{I-3}$$

and T_p is the peak wave period.

I.2 TWO PARAMETER JONSWAP SPECTRUM

The JONSWAP spectrum models relatively high-peaked spectra typically encountered in fetch-limited regions [1,2]. In SEALOADS, a two parameter JONSWAP spectrum with $\gamma = 3.3$ is used as follows:

$$S(\omega) = 0.2044 H_s^2 \frac{\omega_p^4}{\omega^5} \exp[-1.25\frac{\omega_p^4}{\omega^4}]\gamma^{\kappa} \quad \text{(I-4)}$$

$$\kappa = \exp[\frac{-(\omega-\omega_p)^2}{2\sigma^2\omega_p^2}] \quad \text{(I-5)}$$

$$\sigma = \begin{cases} 0.07 & for\ \omega \le \omega_p \\ 0.09 & for\ \omega > \omega_p \end{cases} \quad \text{(I-6)}$$

where ω_p is the peak wave frequency.

I.3 BRETSCHNEIDER SPECTRUM

SEALOADS uses the Bretschneider spectrum taken from the 15th International Towing Tank Conference (ITTC) [1] as follows:

$$S(\omega) = \frac{487}{T_p^4}\frac{H_s^2}{\omega^5}\exp[\frac{-1948}{T_p^4\omega^4}] \quad \text{(I-7)}$$

I.4 OCHI AND HUBBLE SIX PARAMETER SPECTRUM

The Ochi-Hubble six parameter spectrum [3] models collinear swell and sea components as follows:

$$S(\omega) = \frac{1}{4}\sum_{i=1}^{2}\frac{[(\frac{4\lambda_i+1}{4})\omega_{pi}^4]^{\lambda_i}\varsigma_i^2\exp[-(\frac{4\lambda_i+1}{4})(\frac{\omega_{pi}}{\omega})^4]}{\Gamma(\lambda_i)\omega^{(4\lambda_i+1)}} \quad \text{(I-8)}$$

where λ_i, ς_i and ω_{pi} are the spectral shape parameter, significant wave height, and peak frequency for component i, respectively.

I.5 REGULAR WAVES

The surface wave elevation, η, and velocity potential function, ϕ, of regular incident wave can be written as follows:

$$\eta = A\cos[k(x\cos\beta + y\sin\beta) - \omega t] \tag{I-9}$$

$$\phi = \frac{g}{\omega} A e^{kz} \sin[k(x\cos\beta + y\sin\beta) - \omega t] \tag{I-10}$$

where A is the wave amplitude; k is the wave number; β is the wave heading; x, y and z are the coordinates of a field point; ω is the wave frequency; t is time and g is the acceleration of gravity.

I.6 STOKES SECOND-ORDER WAVES

The surface wave elevation and velocity potential of a Stokes second-order wave are as follows [4]:

$$\eta = \frac{H}{2}\cos\theta + \frac{H}{8}\frac{\pi H}{L}\frac{\cosh(kd)}{\sinh^3(kd)}[2 + \cosh(2kd)]\cos 2\theta \tag{I-11}$$

$$\phi = \frac{\pi H}{kT}\frac{\cosh(ks)}{\sinh(kd)}\sin\theta + \frac{3}{8}\frac{\pi H}{kT}\frac{\pi H}{L}\frac{\cosh(2ks)}{\sinh^4(kd)}\sin 2\theta \tag{I-12}$$

where H is the wave height; T is the wave period; L is the wave length; k is the wave number; d is the water depth; $\theta = kx - \omega t$ and ω is the wave frequency; $s = z + d$; and x and z are coordinates of a field point, respectively.

APPENDIX II CPF.CTR

```
# Ship name, job title, user and data

&names
jobtitle='CPF,deep departure, Fn=0.12, Steepness=1/50, Head Seas'
shipname=cpf'
user='qiuw'
date='May 4, 1999'
/

# Principal dimensions

&shipdata
sl=124.5
sb=14.8
sd=4.97
cb=0.5
fn=0.12
rxx=5.18
ryy=31.125
rzz=31.125
xg=-2.656
yg=0.0
zg=1.348
/end(shipdata)

# water density

&waterdensity
waterden=1024.0
/endwaterdensity

# control indices

&controls
presctr=1
sealoadctr=1
motionctr=1
initctr=0
/end(controls)

# output controls

&outputcontrol
outwave=0
/end(outputcontrol)

# damping model

&dampcontrol
dampmodel=0
/end(dampcontrol)

# cross-section for sea loads computation

&xsection
xcx=0.0
/end(xsection)

# time steps for slimulation

&timedata
dt0=0.20
nretar0=200
```

```
nretar =2000
step=0.02
numstep=20000
/end(timedata)

! Non-impulsive coefficient

&impulsecoeff
alfabar=0.1
/end(impulsecoeff)

! Initial conditions

&init_conditions
motion_init=
vel_init   =
acc_init   =
/end(init_conditions)

! input waves

&waves
wavetype=0
beta=180.0
/end(waves)

! regular waves

&regularwave
wamp  = 1.357
wfreq = 0.67
wphase= 0.0
/end(regularwave)

! Two parameter wave spectra - ISSC, JONSWAP and Bretschneider spectra

&twospectrum
Hs=5.0
Tp=11.0
/end(twospectrum)

! Ochi-Hubble six parameter wave spectrum

&OchiHubble
Hs1=
Tp1=
Lambda1=
Hs2=
Tp2=
Lambda2=
/end(ochihubble)

! Measured sprectrum

&measurespectrum
nspec=
specfreq =
spec     =
/end(measurespectrum)

! Stokes wave

&stokeswave
wdepth      = 20.0
stoke_amp   = 2.5
stoke_freq  = 0.9
stoke_phase = 0.0
/end(stokeswave)

! Range of frequencies
```

```
&spectrumrange
numregular=2000
lowfreq   =0.001
upperfreq =2.5
/end(spectrumrange)
```

APPENDIX III CPF.MSH

```
312   248
    1    60.17500     0.00000    -2.96049
    2    60.17627     0.00000    -2.93876
    3    60.32202     0.00000    -2.72316
    4    60.96848     0.00000    -1.77366
    5    61.56566     0.00000    -0.93880
    6    62.25000     0.00000     0.00000
    7    58.02313     0.00000    -4.12256
    8    58.87828     0.10072    -3.20409

  310   -62.25000     4.57625    -0.34250
  311   -62.25000     5.40000     0.00000
  312   -62.25000     5.00196    -0.33770
    1     1     2     8     7
    2     2     3     9     8
    3     3     4    10     9
    4     4     5    11    10
    5     5     6    12    11

  235   281   282   288   287
  236   283   284   290   289
  237   284   285   291   290
```

APPENDIX IV CPF.MASS

```
22
20350.0   65.12   0.0 0.0
57570.0   58.25   0.0 0.0
136130.   51.35   0.0 0.0
152440.   44.07   0.0 0.0
150200.   38.40   0.0 0.0
221180.   33.24   0.0 0.0
298920.   26.18   0.0 0.0
247840.   20.17   0.0 0.0
327890.   15.18   0.0 0.0
296710.    7.87   0.0 0.0
310480.    3.59   0.0 0.0
378400.   -2.42   0.0 0.0
349340.  -10.54   0.0 0.0
263730.  -16.83   0.0 0.0
373920.  -23.03   0.0 0.0
309520.  -30.13   0.0 0.0
215690.  -35.73   0.0 0.0
148290.  -40.09   0.0 0.0
143120.  -46.85   0.0 0.0
170370.  -52.95   0.0 0.0
147150.  -58.79   0.0 0.0
17760.0  -63.41   0.0 0.0
```

APPENDIX V CPF.CHK

```
CPF,deep departure, Fn=0.12, Steepness=1/50, Head Seas
CPF
May 4, 1999
user = qiuw
 Principle Dimensions and Hydrostatics:

Length, between perpendiculars,  Lpp (m):  124.5
Breadth, maximum,                  B (m):  14.8000002
Draft, mean,                       T (m):  4.96999979
Cubic coefficient,                Cb    :  0.5
The Froude number,                Fn    :  0.119999997
Center of Gravity,          (xg,yg,zg) (m): -2.6559999  0.  1.34800005
Radius of gyration,               rxx (m):  5.17999983
Radius of gyration,               ryy (m):  31.125
Radius of gyration,               rzz (m):  31.125
Mass moment of inertia,         ixx(m^3):  124420152.
Mass moment of inertia,         iyy(m^3):  4.49210573E+09
Mass moment of inertia,         izz(m^3):  4.49210573E+09
Volume of displacement,      volume (m^3):  4528.25928
Mass of displacement,          mass (kg) :  4636937.5


 Computed Hydrostatics:

Center of Gravity,          (xg,yg,zg) (m): -2.82247686  0.  0.
Radius of gyration,               rxx (m):  0.
Radius of gyration,               ryy (m):  30.0821381
Radius of gyration,               rzz (m):  30.0821381
Mass moment of inertia,         ixx(m^3):  75857792.
Mass moment of inertia,         iyy(m^3):  3.25779712E+09
Mass moment of inertia,         izz(m^3):  3.2842496E+09
Volume of displacement     volume-x (m^3):  4533.86084
Volume of displacement     volume-y (m^3):  4528.25928
Volume of displacement     volume-z (m^3):  4528.37109
Volume of displacement     volume   (m^3):  4528.25928
Weight of displacement,       mass  (kg) :  4737000.
Area of wetted surface        swet (m^2) :  1979.85803
Area of waterplane             swp (m^2) :  1435.60962
Center of floatation,      (xb,yb,zb) (m) : -2.84567499  0. -1.88667929

          NORMALS IN SIX MODES

  1    0.1146    0.9713   -0.2084    4.6229      12.3145       59.9256
  2    0.1153    0.9834   -0.1402    4.1868       8.2231       61.1024
  -    --        .        -          --           ..           --
```

APPENDIX VI CPF.DATA

```
 124.5  14.8000002  4.96999979  0.5  0.119999997 -2.6559999  0.  1.34800005
 5.17999983  31.125  31.125  4.1937294  4528.25928  4636937.5  124420152.
 4.49210573E+09  4.49210573E+09
22  20350.  57870.  136130.  152440.  150200.  221180.  298920.  247840.
 327890.  296710.  310480.  378400.  349340.  263730.  373920.  309520.
 215690.  148290.  143120.  170370.  147150.  17760.  0.  0.  0.  0.  0.  0.
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  65.1200027  58.25
 51.3499985  44.0699997  38.4000015  33.2400017  26.1800003  20.1700001
 15.1800003  7.86999989  3.58999991 -2.42000008 -10.54 -16.8399999 -23.0300007
-30.1299992 -35.7299995 -40.0900002 -46.8499985 -52.9500008 -58.7900009
-63.4099998  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  23.768158  0.  0.
 2219710.  0.  28.5252132
 0.  0.  0.
```

APPENDIX VII CPF.ADMS

0.413415E+05	0.000000E+00	0.141148E+06	0.000000E+00	0.133109E+08	0.000000E+00
0.000000E+00	0.165050E+07	0.000000E+00	-0.567284E+06	0.000000E+00	0.193329E+08
0.142045E+06	0.000000E+00	0.741822E+07	0.000000E+00	0.584970E+08	0.000000E+00
0.000000E+00	-0.575410E+06	0.000000E+00	0.134968E+08	0.000000E+00	0.927057E+08
0.133001E+08	0.000000E+00	0.585816E+08	0.000000E+00	0.523169E+10	0.000000E+00
0.000000E+00	0.193281E+08	0.000000E+00	0.929456E+08	0.000000E+00	0.162016E+10
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	-0.130467E+09	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	-0.290280E+08
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	-0.591936E+06	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.692176E+07
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	-0.311100E+08	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	-0.241311E+07
0.595698E+06	0.000000E+00	0.311100E+08	0.000000E+00	-0.354976E+06	0.000000E+00
0.000000E+00	-0.692176E+07	0.000000E+00	0.237903E+07	0.000000E+00	-0.204080E+05
0.149551E+05	0.000000E+00	-0.134032E+06	0.000000E+00	0.382343E+07	0.000000E+00
0.000000E+00	0.989920E+06	0.000000E+00	0.876558E+06	0.000000E+00	0.313786E+08
-0.124876E+06	0.000000E+00	0.270290E+07	0.000000E+00	-0.497525E+08	0.000000E+00
0.000000E+00	0.876198E+06	0.000000E+00	0.525635E+07	0.000000E+00	0.577198E+08
0.379493E+07	0.000000E+00	-0.545596E+08	0.000000E+00	0.138270E+10	0.000000E+00
0.000000E+00	0.315028E+08	0.000000E+00	0.575884E+08	0.000000E+00	0.128383E+10
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	-0.475370E+08	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	-0.174101E+08
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.562095E+06	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.415146E+07
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	-0.113352E+08	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.367454E+07
-0.523695E+06	0.000000E+00	0.113352E+08	0.000000E+00	0.201597E+08	0.000000E+00
0.000000E+00	-0.415145E+07	0.000000E+00	-0.367605E+07	0.000000E+00	0.520784E+06
0.263864E+05	0.000000E+00	0.275180E+06	0.000000E+00	0.948747E+07	0.000000E+00
0.000000E+00	0.660583E+06	0.000000E+00	-0.144384E+07	0.000000E+00	-0.120457E+08
0.266921E+06	0.000000E+00	0.471531E+07	0.000000E+00	0.108250E+09	0.000000E+00
0.000000E+00	-0.145161E+07	0.000000E+00	0.824043E+07	0.000000E+00	0.349859E+08
0.950515E+07	0.000000E+00	0.113141E+09	0.000000E+00	0.384900E+10	0.000000E+00
0.000000E+00	-0.121747E+08	0.000000E+00	0.353572E+08	0.000000E+00	0.336330E+09
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	-0.829299E+08	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	-0.116179E+08
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	-0.115403E+07	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.277030E+07
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	-0.197747E+08	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	-0.608765E+07
0.111939E+07	0.000000E+00	0.197747E+08	0.000000E+00	-0.205147E+08	0.000000E+00
0.000000E+00	-0.277030E+07	0.000000E+00	0.605508E+07	0.000000E+00	-0.541192E+06

APPENDIX VIII CPF.GEOM

0.032865	-3.418532	0.520215
0.076484	-2.920429	0.421652
0.112521	-2.255975	1.618515
0.172856	-1.358301	1.974605
0.261594	-0.454150	2.745103
0.112524	-3.907869	2.254531
0.285492	-3.148570	1.744717
0.414458	-2.359323	2.839375
0.577571	-1.421646	2.838422
0.796194	-0.479062	3.117716
0.203072	-4.303938	3.514448
0.543230	-3.348510	2.823730
0.794021	-2.428690	3.137213
1.045803	-1.464217	3.122608
1.341579	-0.492384	3.281622
0.298024	-4.443467	3.682704
0.795521	-3.440398	3.314135
1.161709	-2.456208	3.254949
1.501905	-1.479014	3.234993
1.870163	-0.496685	3.366478
0.392190	-4.473952	3.934644
1.049922	-3.468110	3.587989
1.525922	-2.463423	3.369428
1.946479	-1.482685	3.321756
2.381925	-0.498340	3.443786
0.492468	-4.483559	4.306034
1.318983	-3.480544	3.840914
1.901685	-2.471598	3.457913
2.391279	-1.493572	3.400615
2.883692	-0.503982	3.544146
0.600002	-4.494351	4.762766
1.603462	-3.497526	4.115450
2.290667	-2.493341	3.514022
2.843000	-1.524179	3.484405
3.381618	-0.519099	3.682778
0.709707	-4.512648	5.252426
1.894588	-3.532169	4.413272
2.691892	-2.534567	3.596318
3.305502	-1.572294	3.572371
3.875111	-0.542520	3.834376
0.811074	-4.541779	5.707593
2.176142	-3.594962	4.735846
3.100547	-2.595237	3.805466
3.778686	-1.623381	3.649491
4.357402	-0.567041	3.947628
0.895385	-4.581465	6.075007
2.429302	-3.685646	5.086797
3.500116	-2.671535	4.168455
4.249383	-1.667942	3.711609
4.818130	-0.586216	4.001052
0.958234	-4.628366	6.332618
2.639983	-3.792964	5.460645
3.869540	-2.757164	4.633316
4.694610	-1.704741	3.780217
5.244909	-0.597260	4.009413
1.007607	-4.676352	6.533116
2.821782	-3.902071	5.851299
4.208565	-2.844968	5.109560
5.105557	-1.737806	3.873274
5.633037	-0.603396	3.997846
1.060178	-4.717728	6.783090
3.009468	-3.998152	6.257834
4.535614	-2.927477	5.485371
5.488049	-1.772902	3.975405
5.985254	-0.610838	3.987021
1.120829	-4.747459	7.111969
3.213182	-4.072855	6.674014
4.856483	-2.996529	5.732711

5.839705	-1.804367	4.049855
6.300104	-0.618319	3.976060
1.181476	-4.764534	7.463788
3.414892	-4.125383	7.083937
5.158403	-3.045116	5.913859
6.147925	-1.818121	4.073370
6.571119	-0.618886	3.942836
1.237031	-4.771651	7.798032
3.597660	-4.159388	7.454072
5.422687	-3.076211	6.045363
6.402225	-1.817672	4.068341
6.794347	-0.614215	3.894729
1.287868	-4.773517	8.108871
3.753789	-4.180328	7.738738
5.629143	-3.100816	6.084247
6.598076	-1.822740	4.076087
6.969545	-0.613782	3.876076
1.335847	-4.770065	8.406365
3.887427	-4.187689	7.939080
5.788387	-3.120363	6.033329
6.743312	-1.836539	4.091890
7.100925	-0.618885	3.893291
1.380343	-4.757588	8.692988
4.009693	-4.176994	8.[illegible]06298
5.926838	-3.126877	5.947264
6.855841	-1.844964	4.073387
7.196955	-0.622488	3.908554
1.418288	-4.741713	8.942069
4.117000	-4.155458	8.276031
6.051249	-3.121488	5.857903
6.945918	-1.847094	4.015351
7.266201	-0.624368	3.918864
1.442708	-4.734944	9.099148
4.193457	-4.139350	8.445858
6.145060	-3.113971	5.761927
7.012744	-1.855991	3.946911
7.325059	-0.631471	3.961252
1.458988	-4.737631	9.196679
4.241768	-4.127652	8.569422
6.198636	-3.101961	5.640537
7.049713	-1.871277	3.870728
7.343855	-0.644503	4.039832
1.485913	-4.739009	9.338562
4.282762	-4.103616	8.581776
6.215463	-3.072883	5.472723
7.049676	-1.879035	3.771964
7.349053	-0.657292	4.121128
1.512384	-4.727845	9.534083
4.322141	-4.064172	8.493098
6.205925	-3.033216	5.264323
7.020339	-1.879305	3.674419
7.335420	-0.667522	4.190297
1.534113	-4.709260	9.686838
4.344454	-4.021680	8.378244
6.181026	-3.006324	5.057333
6.981346	-1.885844	3.634459
7.314388	-0.676888	4.253140
1.530358	-4.683385	9.692768
4.320593	-3.978992	8.264985
6.131738	-2.996715	4.920436
6.936393	-1.896880	3.665719
7.285738	-0.682764	4.291927
1.488618	-4.649537	9.478348
4.217610	-3.924848	8.128263
6.031486	-2.976318	4.925601
6.870588	-1.894517	3.731876
7.237266	-0.678613	4.271724
1.407677	-4.600466	9.058414
4.030470	-3.841361	7.961569
5.868225	-2.931890	5.056360

6.769606	-1.871858	3.785543
7.161592	-0.665854	4.206254
1.297853	-4.321377	8.537498
3.784242	-3.708652	7.783470
5.649253	-2.851067	5.199605
6.625515	-1.834891	3.788238
7.059353	-0.653266	4.153174
1.174870	-4.390519	8.033585
3.510476	-3.516583	7.584889
5.390654	-2.728171	5.275394
6.441978	-1.784306	3.742019
6.934771	-0.642650	4.125579
1.056723	-4.182423	7.589902
3.238939	-3.267390	7.330752
5.113470	-2.561832	5.275687
6.232859	-1.713182	3.677997
6.793234	-0.627720	4.084808
0.955146	-3.879495	7.125545
2.990359	-2.974597	7.006394
4.835971	-2.356394	5.220478
6.009928	-1.615678	3.604743
6.637501	-0.603752	4.002564
0.874025	-3.479070	6.521286
2.775566	-2.660190	6.630077
4.571587	-2.122901	5.127680
5.780445	-1.490617	3.510893
6.467932	-0.569554	3.873295
0.813176	-3.011536	5.822964
2.597712	-2.343107	6.230090
4.328599	-1.879779	4.992651
5.551085	-1.346191	3.415300
6.286260	-0.525939	3.695946
0.769364	-2.538474	5.225262
2.454349	-2.036674	5.834766
4.111372	-1.648654	4.809958
5.329940	-1.198431	3.351667
6.096691	-0.474907	3.468687
0.739410	-2.106856	4.824097
2.343574	-1.750180	5.474314
3.926043	-1.437775	4.604167
5.126387	-1.056028	3.295034
5.906671	-0.419813	3.207420
0.721323	-1.737394	4.467951
2.264296	-1.491042	5.030594
3.780204	-1.243745	4.293127
4.950171	-0.920172	3.099696
5.727530	-0.365216	2.871014
0.711416	-1.442436	3.610468
2.211614	-1.271764	3.987052
3.675793	-1.074927	3.438857
4.811247	-0.800959	2.449128
5.575634	-0.318188	2.210059
0.704626	-1.226642	2.332338
2.176830	-1.106135	2.534619
3.607351	-0.949649	2.199572
4.717410	-0.716111	1.540384
5.467402	-0.286387	1.367513
0.698121	-1.072211	1.578030
2.151881	-0.987005	1.703151
3.563600	-0.865654	1.481845
4.660978	-0.665373	1.029264
5.399021	-0.269419	0.896204
0.691701	-0.944879	1.402932
2.131166	-0.888678	1.511553
3.530405	-0.799939	1.317641
4.620999	-0.629568	0.912325
5.348565	-0.258721	0.776353
0.686376	-0.831988	1.158793
2.113796	-0.800020	1.246913
3.502503	-0.739516	1.089337

4.587556	-0.596078	0.752009
5.305357	-0.248652	0.624490
0.683589	-0.743826	0.766720
2.102823	-0.727031	0.823053
3.483390	-0.685371	0.721019
4.563836	-0.563034	0.495465
5.273617	-0.237700	0.401478
0.683325	-0.680430	0.529652
2.098245	-0.669731	0.566478
3.473095	-0.637509	0.497874
4.549912	-0.530428	0.340048
5.253137	-0.225974	0.268904
0.684065	-0.627338	0.480360
2.096314	-0.618785	0.510988
3.466538	-0.591944	0.450332
4.540240	-0.497660	0.305691
5.237512	-0.213689	0.236036
0.684974	-0.572071	0.459595
2.094594	-0.565218	0.485750
3.459999	-0.543514	0.429044
4.530475	-0.462572	0.289133
5.221543	-0.200551	0.217323
0.686044	-0.505111	0.450781
2.092460	-0.500329	0.472521
3.451924	-0.484842	0.418111
4.518447	-0.420085	0.278820
5.202134	-0.184675	0.202180
0.687587	-0.407318	0.545359
2.089310	-0.405613	0.564701
3.440028	-0.399174	0.500711
4.500774	-0.358049	0.328617
5.173813	-0.161602	0.225297
0.341653	-0.173650	0.237312
1.024960	-0.173651	0.237314
1.729382	-0.173649	0.251978
2.454920	-0.173649	0.251980
3.150898	-0.173651	0.231446
3.817315	-0.173652	0.231447
4.415579	-0.161471	0.180911
4.947293	-0.159042	0.177914
0.971298	-0.208440	
0.983378	-0.140244	
0.985952	-0.102582	
0.979721	-0.133556	
0.966228	-0.186684	
0.966594	-0.238917	
0.968302	-0.222768	
0.978386	-0.157731	
0.969249	-0.189668	
0.948043	-0.267343	
0.931722	-0.358843	
0.951627	-0.292522	
0.962735	-0.242486	
0.955350	-0.257250	
0.934412	-0.316894	
0.863685	-0.502916	
0.924528	-0.372829	
0.940277	-0.322245	
0.934199	-0.330419	
0.918822	-0.363688	
0.784734	-0.619269	
0.884371	-0.460547	
0.914343	-0.390012	
0.910447	-0.392686	
0.901142	-0.408068	
0.703238	-0.710504	
0.836948	-0.541904	
0.886695	-0.448855	
0.898770	-0.439470	
0.885395	-0.442288	

0.621731	-0.782814
0.788016	-0.610670
0.855832	-0.504588
0.868657	-0.476977
0.877383	-0.457946
0.542108	-0.839933
0.737764	-0.670427
0.821352	-0.558468
0.850635	-0.507661
0.880751	-0.451626
0.467184	-0.883829
0.681586	-0.727565
0.787432	-0.605212
0.837502	-0.529054
0.894335	-0.425058
0.398260	-0.916995
0.620948	-0.780501
0.757086	-0.643711
0.832998	-0.537568
0.912025	-0.388034
0.335923	-0.941665
0.563200	-0.823865
0.728049	-0.678002
0.839310	-0.530060
0.926678	-0.355481
0.279883	-0.959854
0.511605	-0.857248
0.701962	-0.705975
0.851693	-0.511564
0.938647	-0.326162
0.231625	-0.972680
0.464958	-0.883672
0.684460	-0.723464
0.862728	-0.493874
0.953038	-0.284626
0.194861	-0.980766
0.421698	-0.905533
0.677736	-0.730612
0.872955	-0.477934
0.967706	-0.234663
0.171398	-0.985179
0.381131	-0.923807
0.680578	-0.729156
0.886981	-0.454647
0.976977	-0.198796
0.158343	-0.987377
0.345693	-0.937961
0.689167	-0.722216
0.901611	-0.427650
0.981643	-0.180234
0.150828	-0.988557
0.319131	-0.947514
0.698599	-0.714085
0.909067	-0.413611
0.985665	-0.161713
0.148097	-0.988973
0.299811	-0.953925
0.706744	-0.706569
0.911009	-0.410597
0.989481	-0.140188
0.152074	-0.988363
0.282778	-0.959175
0.713790	-0.699697
0.916887	-0.398019
0.991402	-0.128293
0.158901	-0.987290
0.269256	-0.963068
0.718439	-0.695164
0.927597	-0.372816
0.991790	-0.126530

0.160809	-0.986985
0.265722	-0.964048
0.718301	-0.695557
0.935432	-0.353044
0.992307	-0.123098
0.157288	-0.987550
0.274246	-0.961659
0.715402	-0.698703
0.936557	-0.350434
0.993067	-0.117382
0.154957	-0.987921
0.291301	-0.956608
0.715761	-0.698287
0.931558	-0.363545
0.992824	-0.119571
0.158089	-0.987420
0.309016	-0.951005
0.720668	-0.693156
0.922156	-0.386646
0.991604	-0.129175
0.167541	-0.985844
0.317206	-0.948287
0.724226	-0.689485
0.911339	-0.411544
0.990715	-0.135791
0.184090	-0.982853
0.314691	-0.948997
0.716614	-0.697249
0.902346	-0.430801
0.990277	-0.138665
0.210524	-0.977451
0.309531	-0.950269
0.687919	-0.724908
0.896365	-0.442603
0.988875	-0.147379
0.254075	-0.966816
0.304476	-0.951009
0.639988	-0.766431
0.888335	-0.457509
0.985352	-0.168021
0.323377	-0.945314
0.295374	-0.952430
0.584148	-0.808439
0.868217	-0.493310
0.979048	-0.200285
0.411658	-0.909071
0.281473	-0.954997
0.525099	-0.846730
0.830013	-0.554074
0.969536	-0.241198
0.493231	-0.865430
0.266642	-0.957757
0.461265	-0.882158
0.774624	-0.628411
0.956396	-0.288181
0.541151	-0.833580
0.253107	-0.960630
0.396405	-0.912586
0.704915	-0.705109
0.938657	-0.340862
0.535120	-0.834278
0.239652	-0.964080
0.340858	-0.934642
0.623211	-0.777848
0.914926	-0.399578
0.471568	-0.870056
0.223427	-0.968563
0.297615	-0.949842
0.536995	-0.839817
0.885180	-0.461317

0.372545	-0.917528
0.199224	-0.974690
0.259393	-0.962023
0.462878	-0.883398
0.851519	-0.520677
0.268718	-0.954997
0.167828	-0.981547
0.221970	-0.972176
0.410075	-0.909646
0.813877	-0.577980
0.180036	-0.977647
0.136531	-0.987222
0.188010	-0.979809
0.371136	-0.926622
0.768889	-0.637066
0.115950	-0.988121
0.109861	-0.990821
0.159171	-0.985130
0.337378	-0.939733
0.720559	-0.691626
0.075536	-0.991404
0.086541	-0.992723
0.133476	-0.988978
0.306651	-0.950521
0.684832	-0.727338
0.051111	-0.991746
0.064753	-0.993670
0.109018	-0.991964
0.278853	-0.959363
0.669212	-0.742012
0.033362	-0.992130
0.043830	-0.994576
0.085185	-0.994261
0.252415	-0.966721
0.663507	-0.747177
0.018691	-0.992250
0.025603	-0.994779
0.063779	-0.995442
0.226987	-0.972773
0.657864	-0.752081
0.009429	-0.991519
0.013977	-0.993490
0.048456	-0.994670
0.204239	-0.976824
0.648936	-0.759546
0.005756	-0.990189
0.009193	-0.991095
0.039436	-0.992193
0.184398	-0.978938
0.636395	-0.769680
0.004550	-0.988929
0.007424	-0.989564
0.033183	-0.990861
0.165784	-0.981306
0.621520	-0.781478
0.003633	-0.984695
0.005970	-0.985583
0.026864	-0.987762
0.145608	-0.982656
0.603826	-0.794515
0.002521	-0.973257
0.004170	-0.974804
0.019139	-0.979025
0.120426	-0.981043
0.579843	-0.810280
0.000939	-0.953013
0.001577	-0.955678
0.007956	-0.963307
0.083089	-0.976001
0.539988	-0.834109

0.000000	0.000000
0.000000	0.000000
0.000000	0.000000
0.000000	0.000000
0.000000	0.000000
0.000000	0.000000
0.000000	0.000000
0.000000	0.000000

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1 INTRODUCTION

This chapter is associated with the DIF (DIFfraction) module of the SEALOADS package. The DIF module is responsible for computing the response function due to the diffracted waves.

The main text of this chapter describes input/output files and their formats and records.

2 INPUT AND OUTPUT FILES

2.1 INPUT FILES

To run DIF, the user needs to provide the following input files:

1. <filename>.ctr — main input file containing:
   - Principal ship dimensions and hydrostatics
   - Physical constants
   - Control indices for computing options
   - Time step data
   - Initial conditions
   - Incident wave information.
2. <filename>.data — input file from the RAD module containing main ship data and hydrostatics
3. <filename>.msh — containing the information on nodes and panels under the waterline

where <filename> is a suitable name string up to 25 characters in length.

Note that RAD, DIF, DAMP and SEALOAD share the same input files: <filename>.ctr and <filename>.msh. The format and description of these two files are given in Sections 3 and 4, PART II. Examples of input files are presented in Appendices III, IV and V, PART II. The format and description of <filename>.data are given in Section 5, Part II and the example of this file is in Appendix VII, Part II. The organization of DIF input/output files is shown in Figure 2.1. **Users must not alter the three input files after running the RAD program.**

2.2 OUTPUT FILES

DIF produces the following output files:

1.	<filename>.ki7f	Contains the response functions of total forces due to the diffracted waves
2.	<filename>.ki7fx	Contains the response functions of sea loads acting on a given cross section due to the diffracted waves
3.	<filename>.ki7p	Contains the response functions of pressures on each panel centroid due to the diffracted waves.

The format and description of output files are given in Section 3.

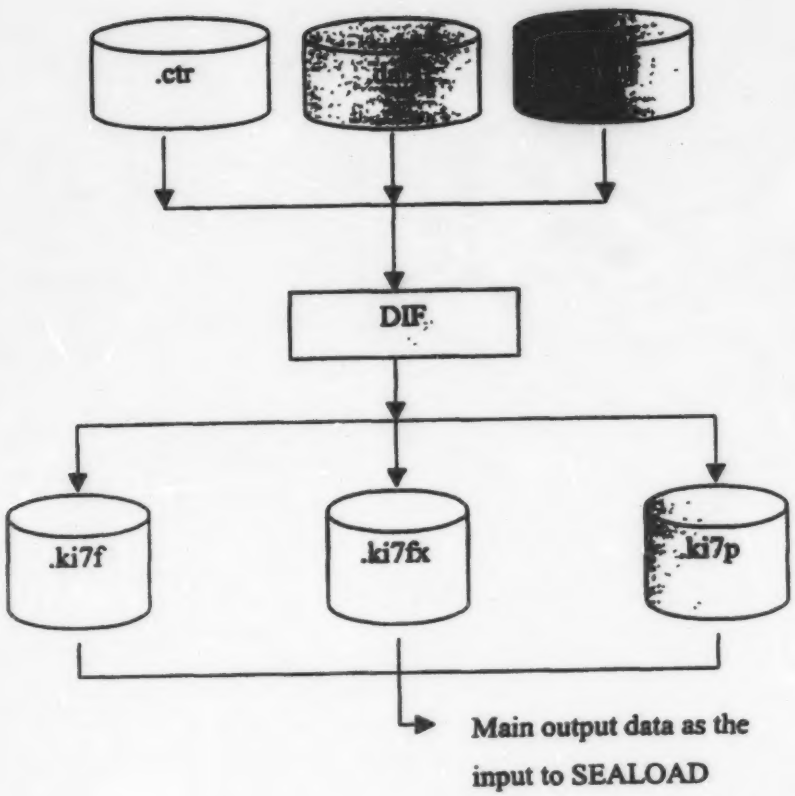

Figure 2.1 Organization of program DIF

3 DESCRIPTION OF OUTPUT FILES

A brief description of the records in the output files <filename>.ki7f, <filename>.ki7fx, and <filename>.ki7p is presented.

3.1 <FILENAME>.KI7F

This file contains the response function of the total force acting on the ship due to diffracted waves. It is an input file to SEALOAD.

Time	Response function
t(1)	Response function $K_{i7}(6)$ at time 0
t(2)	Response function K_{i7} at time $t = step$
t(3)	Response function K_{i7} at time $t = 2 \times step$
...	...
t(nretar-1)	Response function K_{i7} at time $t = (nretar - 1) \times step$
t(nretar)	Response function K_{i7} at time $t = nretar \times step$

3.2 <FILENAME>.KI7FX

This file contains the response functions of sea loads acting on the fore-body due to diffracted waves. It is an input file to SEALOAD.

Time	Response function
t(1)	Response function $K_{i7}^{X}(6)$ at time 0
t(2)	Response function K_{i7}^{X} at time $t = step$
t(3)	Response function K_{i7}^{X} at time $t = 2 \times step$

...	...
t(nretar-1)	Response function K_{i7}^{x} at time $t = (nretar - 1) \times step$
t(nretar)	Response function K_{i7}^{x} at time $t = nretar \times step$

3.3 <FILENAME>.KI7P

This file contains the response functions of pressure on each panel due to diffracted waves. It is an input file to SEALOAD for the pressure distribution computation. If Presctr=0, this file won't be produced.

Time	Response function
t(1)	Response function $K_{i7}^{p}(Npanel)$ at time $t = 0$
t(2)	Response function K_{i7}^{p} at time $t = step$
t(3)	Response function K_{i7}^{p} at time $t = 2 \times step$
...	...
t(nretar-1)	Response function K_{i7}^{p} at time $t = (nretar - 1) \times step$
t(nretar)	Response function K_{i7}^{p} at time $t = nretar \times step$

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1 INTRODUCTION

This part describes the DAMP module of the SEALOADS package. The DAMP module is responsible for computing the viscous roll damping coefficient.

The main text describes input/output files and their formats and records.

Examples of output files for a Canadian Patrol Frigate (CPF) are presented in Appendices I and II.

2 INPUT AND OUTPUT FILES

2.1 INPUT FILES

To run DAMP, the user needs to provide the following input files:

1. <filename>.ctr — main input file contains:
   - Principal ship dimensions and hydrostatics
   - physical constants
   - Control indices for options
   - Time step data
   - Initial condition
   - Incident wave information.
2. <filename>.geom — contains panel geometry information.
3. <filename>.b44 — contains roll decay test data and the GZ curve.
4. <filename>.b44f — contains information for computing the roll damping coefficient with empirical formulae.

where <filename> is a suitable name string up to 25 characters in length.

RAD, DIF, DAMP and SEALOAD share the same input file: <filename>.ctr. The format and description of the file are given in Sections 3, PART II. Examples of input files are presented in Appendix III, PART II. The format and description of <filename>.b44 and <filename>.b44f are given in Section 3. Respective examples are presented in Appendices I and II. An example of <filename>.geom is shown in Appendix VIII, Part II.

2.2 OUTPUT FILES

DAMP produces the following output files:

1. <filename>.damp Contains viscous roll damping coefficients.

The format and description of output files are given in Section 4 and an example of the output file is given in Appendix III.

The organization of the input/output files is shown in Fig.2.1.

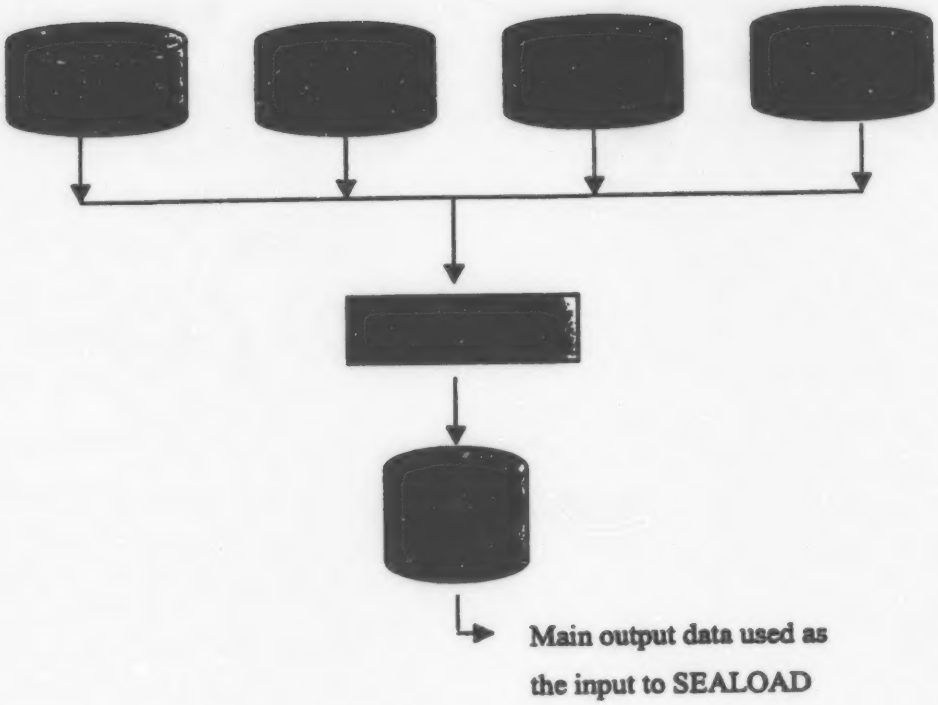

Figure 2.1 Organization of program DAMP

3 FORMAT OF INPUT FILES

The following is the format of the input files <filename>.b44, and <filename>.b44f. The definitions of records for these files are given in Section 4. Comment lines can be introduced by making '#' as the first character of the line. The program does not differentiate lower or upper case characters.

3.1 FORMAT OF <FILENAME>.B44

period, numdecay, numgz

decayt(i), decayangle(i) i=1, 2, ..., numdecay

gzangle(i), gzvalue(i) i=1, 2, ..., numgz

3.2 FORMAT OF <FILENAME>.B44F

control data for viscous damping computation

&b44controls

ibk

ibe

ibf

iba

ibl

ns

/end{b44controls}

bilge geometry

&bilgegeom

ns0
ns1
bilgeb
ratiolb
/end{bilgegeom}

kinematic viscosity of water

&viscosity
viscoef
/end{viscosity}

sectional parameters - a
&sectionparameter_a
ship_i
ship_s
ship_b
ship_kg
ship_d
/end{sectionparameter_a}

sectional parameter – b

&sectionparameter_b
ship_rhat
ship_a
ship_r
ship_rb
ship_lk
/end{sectionparameter_b}

```
# section parameter – c

&sectionparameter_c
ship_g
ship_ss
ship_f_r
ship_a_g
/end{sectionparameter_c}

# rudder parameters

&rudderparameter
skegspan
vcg
rudderspan
skegangle
rudderarea
/end{rudderparameter}

# appendages

&appendages
numapp
nfcoef
app_y
app_z
app_g
app_c_e
app_c_r
```

app_b
/end{appendages}

4 DISCRIPTION OF INPUT FILES

4.1 DESCRIPTION OF <FILENAME>.B44

4.1.1 CONTROL RECORD

period - period of roll, *second.*
numdecay - number of roll decay test data (maximum 3000).
numgz - number of GZ curve points (maximum 3000).

4.1.2 ROLLDECAY RECORD

decayt(i) - time, *second*, i=1, 2, ..., numdecay.
decayangle(i) - roll angle, *degree*, i=1, 2, ..., numdecay.

4.1.3 GZCURVE RECORD

gzangle(i) - roll angle, *degree*, i=1, 2, ..., numgz.
gzvalue(i) - moment arm, *meter*, i=1, 2, ..., numgz.

4.2 DESCRIPTION OF <FILENAME>.B44F

4.2.1 CONTROLS RECORD

ibk =1, bilge keel viscous roll damping coefficient will be computed;
=0, bilge keel viscous roll damping coefficient won't be computed.
ibe =1, eddy-making viscous roll damping coefficient will be computed;
=0, eddy-making viscous roll damping coefficient won't be computed.
ibf =1, friction viscous roll damping coefficient will be computed;

=0, friction viscous roll damping coefficient won't be computed.

iba =1, appendage (other than bilge keel) viscous roll damping coefficient will be computed;

=0, appendage (other than bilge keel) viscous roll damping coefficient won't be computed.

ibl =1, lifting viscous roll damping coefficient of rudder and skeg will be computed;

=0, lifting viscous roll damping coefficient of rudder and skeg will be computed;

ns - total number of sections (maximum 25)

The above record must not be omitted.

4.2.2 BILGEGEOM RECORD

ns0 - station number of the section where the bilge keel starts.

ns1 - station number of the section where the bilge keel ends.

bilgeb - bilge keel width, *meter*.

ratiolb - bilge width-length ratio.

4.2.3 VISCOSITY RECORD

viscoef - kinematic viscosity of water, m^2/s.

4.2.4 SECTIONPARAMETER_A RECORD

ship_i(i) - sectional shape identifier, i=1, 2, …, ns

=1, for V or U-shaped section,

=2, for full-almost rectangular section,

=3, triangular section.

ship_s(i) - wetted surface area of the segment at section *i*, *meter*^{2}. (see Figure 1)

ship_b(i) - sectional beam, *meter*.

ship_kg(i) - height of ship's CG above the lowest point at each section, *meter*.

ship_d(i) - sectional draught, *meter*.

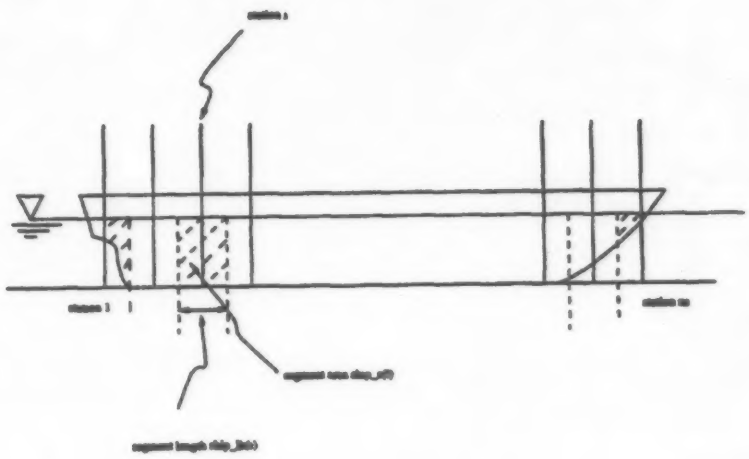

Figure 1. Sectional geometry definition

4.2.5 SECTIONPARAMETER_B RECORD

ship_rhat(i) - distance from ship's CG to the point where eddies are shed, in the *yz* plane, *meter*, i=1, 2, …, ns.

ship_a(i) - inclination angle of ship side at the section waterline, *degree* (Figure 2).

ship_r(i) - distance from the CG to the center of the bilge keel at each section, *meter*. If no bilge keel, set the value to zero.

ship_rb(i) - sectional bilge radius, *meter*.

ship_lk(i) - segment length, *meter*. (Figure 1)

4.2.6 SECTIONPARAMETER_C RECORD

ship_g(i) - angle between waterlines, from the center of gravity to the bilge keel root and DWL, *radian*, i=1, 2, ..., ns. (Figure 3)

ship_ss(i) - length of girth from the bilge keel root to DWL, *meter*. (Figure 2)

ship_f_r(i) - sectional deadrise, *meter*. (Figure 2)

ship_a_g(i) - angle made by the plane of the bilge keel with the straight line passing through CG and the bilge root, *radian*. (Figure 3)

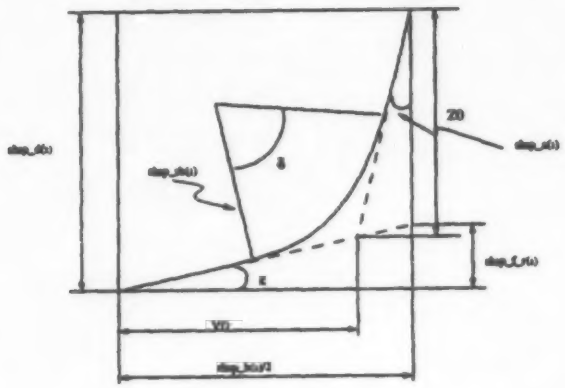

Figure 2. Cross sectional parameters

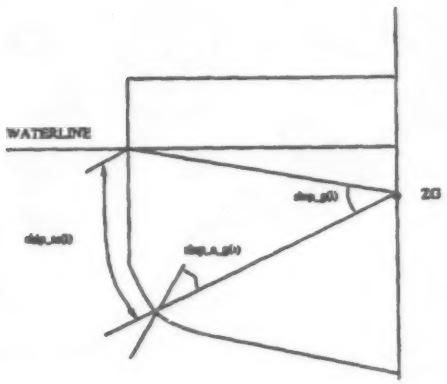

Figure 3. Bilge keel parameters

4.2.7 RUDDERPARAMETER RECORD

skegspan - skeg span, *meter*. (Figure 4)

vcg - vertical distance of CG above waterline, *meter*. (Figure 4)

rudderspan - rudder span, *meter*. (Figure 4)

skegangle - skeg angular parameter, *radian*. (Figure 4)

rudderarea - rudder planform area, $meter^2$.

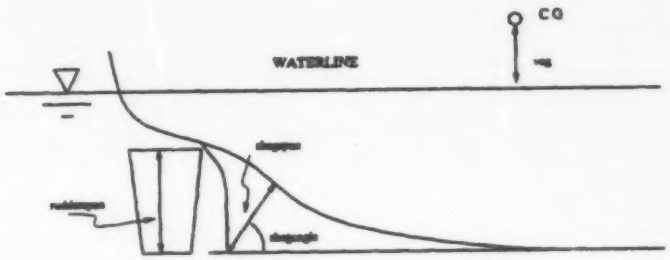

Figure 4. Skeg and rudder parameters

4.2.8 APPENDAGES RECORD

numapp - total number of appendages (maximum 25).

nfcoef - normal force coefficient for a flat plate inclined at a large angle to the flow.

app_y(i) - y-coordinate of appendage *i*, *meter*, i=1, 2, …, numapp. (Figure 5)

app_z(i) - y-coordinate of appendage *i*, *meter*. (Figure 5)

app_g(i) - dihedral angle of appendage *i*, *degree*. (Figure 5)

app_c_e(i) - end chord of appendage *i*, *meter*. (Figure 6)

app_c_r(i) - root chord of appendage *i*, *meter*. (Figure 6)

app_b(i) - span of appendage *i*, *meter*. (Figure 6)

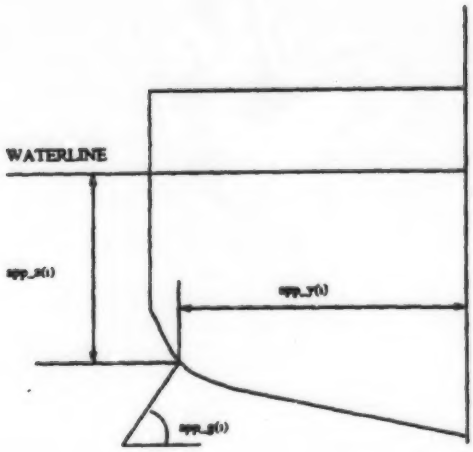

Figure 5. Appendage parameters

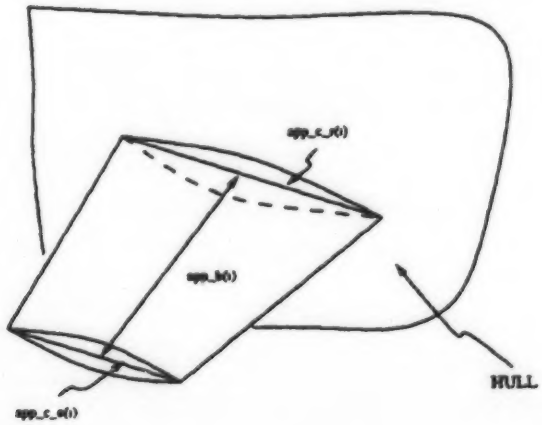

Figure 6. An example of appendage parameters

F2

5 DESCRIPTION OF <FILENAME>.DAMP

The following is a brief description of the records in the output file <filename>.damp. An example of this file is given in Appendix II.

5.1 <FILENAME>.DAMP

dampcoeff(1), dampcoeff(2) - damping coefficients which are described in Part II.

APPENDIX I CAPE.B44

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        1.9000      -17.7610
        1.9200      -17.3030
        1.9400      -16.8450
        1.9600      -16.1330
        1.9800      -15.4700
        2.0000      -14.7490
        2.0200      -13.9860
        2.0400      -13.1650
        2.0600      -12.3270
        2.0800      -11.4410
        2.1000      -10.5380
        2.1200       -9.5860
        2.1400       -8.6320
        2.1600       -7.6590
        2.1800       -6.6800
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        2.3600        2.3590
        2.3800        3.3210
        2.4000        4.2530
        2.4200        5.1530
        2.4400        6.0630
        2.4600        6.9280
        2.4800        7.7640
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        2.5600       10.7570
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        2.7600       15.1000
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        2.9000       15.0820
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        2.9400       14.7000
        2.9600       14.4130
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3.1000	11.3120
3.1200	10.7430
3.1400	10.0790
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13.1200	1.0410
13.1400	1.2100
13.1600	1.3890
13.1800	1.5830
13.2000	1.6740
13.2200	1.8380
13.2400	1.9840
13.2600	2.1110
13.2800	2.1770
13.3000	2.3660
13.3200	2.4710
13.3400	2.5760
13.3600	2.6940
13.3800	2.7710
13.4000	2.8440
13.4200	2.8430
13.4400	2.9640
13.4600	3.0130
13.4800	3.0460
13.5000	3.0660
13.5200	3.1020
13.5400	3.0990
13.5600	3.0870
13.5800	3.0310
13.6000	3.0480
13.6200	3.0360
13.6400	2.9700
13.6600	2.9570
13.6800	2.8400
13.7000	2.7910
13.7200	2.7020
13.7400	2.6200
13.7600	2.4980
13.7800	2.4250
13.8000	2.2930
13.8200	2.1750
13.8400	2.0760

13.8600	1.9060
13.8800	1.7530
13.9000	1.6260
13.9200	1.4590
13.9400	1.3220
13.9600	1.0700
13.9800	.9970
14.0000	.8400
14.0200	.6760
14.0400	.4920
14.0600	.3370
14.0800	.1720
14.1000	.0050
14.1200	-.1530
14.1400	-.3370
14.1600	-.4900
14.1800	-.6370
14 2000	-.7860
14.2200	-.9340
14.2400	-1.0730
14.2600	-1.2360
14.2800	-1.3500
14.3000	-1.4640
14.3200	-1.5760
14.3400	-1.6950
14.3600	-1.7800
14.3800	-1.8810
14.4000	-1.9720
14.4200	-2.0470
14.4400	-2.1270
14.4600	-2.1850
14.4800	-2.2230
14.5000	-2.2610
14.5200	-2.3110
14.5400	-2.3090
14.5600	-2.3220
14.5800	-2.3230
14.6000	-2.3120
14.6200	-2.2880
14.6400	-2.2850
14.6600	-2.2270
14.6800	-2.1820
14.7000	-2.0910
14.7200	-2.0560
14.7400	-1.9880
14.7600	-1.9030
14.7800	-1.8500
14.8000	-1.7250
14.8200	-1.6310
14.8400	-1.5100
14.8600	-1.3990
14.8800	-1.2650
14.9000	-1.2210
14.9200	-1.0100
14.9400	-.8710
14.9600	-.7170
14.9800	-.6490
15.0000	-.4440
15.0200	-.2940
15.0400	-.1510
15.0600	.0000
15.0800	.1430
15.1000	.3100
15.1200	.4750
15.1400	.6150
15.1600	.7640
15.1800	.9200
15.2000	1.0430

15.2200	1.2100
15.2400	1.3590
15.2600	1.4750
15.2800	1.6200
15.3000	1.7260
15.3200	1.8500
15.3400	1.9630
15.3600	2.0720
15.3800	2.1640
15.4000	2.2740
15.4200	2.3540
15.4400	2.3540
15.4600	2.4920
15.4800	2.5680
15.5000	2.6200
15.5200	2.6700
15.5400	2.6880
15.5600	2.7320
15.5800	2.7620
15.6000	2.7490
15 6200	2.7370
15.6400	2.7560
15.6600	2.7230
15.6800	2.7170
15.7000	2.6830
15.7200	2.6300
15.7400	2.5850
15.7600	2.5440
15.7800	2.4970
15.8000	2.3920
15.8200	2.3440
15.8400	2.2620
15.8600	2.1750
15.8800	2.0890
15 9000	1.9820
15.9200	1.8780
15.9400	1.7870
15.9600	1.6650
15.9800	1.5390
16.0000	1.4220
16.0200	1.3010
16.0400	1.1540
16.0600	.9150
16.0800	.8870
16.1000	.7580
16.1200	.6200
16.1400	.4910
16.1600	.3830
16.1800	.2270
16.2000	.0820
16.2200	-.0420
16.2400	-.1530
16.2600	-.2960
16.2800	-.4250
16.3000	-.4970
16.3200	-.6420
16.3400	-.7540
16.3600	-.8590
16.3800	-.9680
16.4000	-1.0270
16.4200	-1.1260
16.4400	-1.2580
16.4600	-1.2960
16.4800	-1.3550
16.5000	-1.3840
16.5200	-1.4410
16.5400	-1.4990
16.5600	-1.5190

```
16.5800          -1.5780
0.0   0.0
5.0   0.011
10.0  0.023
15.0  0.034
20.0  0.043
25.0  0.047
```

APPENDIX II CPF.B44F

```
# input data of CPF for estimation of roll damping coefficents

# control data

&b44controls
IBK=1
ibe=1
ibf=1
iba=0
ibl=1
ns=21
/end(b44controls)

# bilge geometry

&bilgegeom
ns0=6
ns1=14
bilgeb=0.8
ratiolb=0.01606
/end(bilgegeom)

# kinematic viscousity of water

&viscosity
viscoef=1.14e-06
/end(viscosity)

# seciontional parameter - a

&sectionparameter_a
ship_i = 3 3 3 3 1 1 1 1 1 1
         1 1 1 1 1 1 1 1 3 3 3
ship_s = 0.0    74.07  82.09  92.13  104.24 115.14 118.72 122.43 124.29 124.29
         124.06 122.09 118.15 111.72 103.33  93.47  83.93  74.26  61.42  61.37 0.0
ship_b = 0.000 11.61 12.35 13.02 13.62 14.13 14.52 14.78 14.89 14.89
         14.80 14.53 14.04 13.24 12.11 10.66  8.89  6.85  4.67  2.51 0.0
ship_kg= 1.87 2.83 3.53 4.62 5.98 6.50 6.50 6.50 6.50 6.50
         6.50 6.50 6.50 6.50 6.50 6.50 6.50 6.50 6.50 6.37 1.87
ship_d = 0.37 1.33 2.03 3.12 4.48 5.00 5.00 5.00 5.00 5.00
         5.00 5.00 5.00 5.00 5.00 5.00 5.00 5.00 5.00 4.87 0.37
/end(sectionparameter_a)

# sectional parameters - b

&sectionparameter_b
ship_rhat = 1.87 2.83 3.53 4.62 5.98 6.90 7.26 7.52 7.61 7.66
            7.66 7.52 6.86 6.53 6.50 6.50 6.50 6.50 6.50 6.37 1.87
ship_a    = 0.00 38.7 32.6 25.8 21.0 13.0 8.00 7.00 4.00 4.00
            6.00 7.50 9.00 14.0 19.0 29.8 31.6 28.5 21.4 18.9 0.00
ship_r    = 0.06 0.06 0.06 0.06 0.06 7.11 7.61 7.86 7.96 8.06
            8.06 7.86 7.26 6.88 0.06 0.06 0.06 0.06 0.06 0.06 0.06
ship_rb   = 0.00 0.00 0.00 0.00 0.00 2.50 2.66 2.60 2.73 2.80
            2.86 2.80 2.70 2.50 0.00 0.00 0.00 0.00 0.00 0.00 0.00
ship_lk   = 3.113 6.225 6.225 6.225 6.225 6.225 6.225 6.225 6.225 6.225
            6.225 6.225 6.225 6.225 6.225 6.225 6.225 6.225 6.225 6.310 3.113
/end(sectionparameter_b)

# sectional parameters - c

&sectionparameter_c
ship_g    = 0.419 0.419 0.419 0.419 0.419 0.419 0.422 0.427 0.436 0.436
            0.419 0.410 0.401 0.383 0.383 0.383 0.383 0.383 0.383 0.383 0.383
```

```
ship_ss   = 0.000 0.000 0.000 0.000 0.000 3.440 3.590 3.710 3.750 3.770
            3.710 3.630 3.420 2.990 0.000 0.000 0.000 0.000 0.000 0.000 0.000
ship_f_r  = 0.000 0.000 0.000 0.000 0.000 1.234 1.271 1.292 1.304 1.304
            1.294 1.273 1.227 1.153 0.000 0.000 0.000 0.000 0.000 0.000 0.000
ship_a_g  = 0.262 0.262 0.262 0.262 0.262 0.262 0.262 0.261 0.260 0.260
            0.253 0.250 0.250 0.250 0.250 0.250 0.250 0.250 0.250 0.250 0.250
/end(sectionparameter_c)

$ rudder parameters

&rudderparameter
skegspan = 5.2
vcg      = 1.138
rudderspan = 5.30
skegangle  = 0.96666
rudderarea = 19.0
/end(rudderparameter)

$ appendages

&appendages
numapp = 0
nfcoef = 0.0
/end(appendages)
```

APPENDIX III CPF.DAMP

```
25587226.  81917248.
```

PART V KERNEL PROGRAM: SEALOAD

SEALOADS V1.0 – PART V

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1 INTRODUCTION

This part of the User's Guide describes the use of the program SEALOAD. The main program SEALOAD calculates the exciting forces, sea loads and pressure distribution in the time domain. The radiation and diffraction forces are computed from the response functions, which are calculated in RAD and DIF. The nonlinear Froude-Krylov forces are computed at the instantaneous position using a 3-D panel method. Viscous damping, resistance, propeller thrust, rudder and maneuvering forces are also included. The SEALOAD program gives output in terms of sea loads acting on a cross section and the pressure distribution over the ship hull.

The main text of this chapter describes the input/output files and their formats and records.

The theoretical background for computing resistance, cross-flow drag, propeller thrust, maneuvering force, rudder force and slamming force is presented in Appendices I to V.

Appendices VI and VII give examples of two input files for a Canadian Patrol Frigate (CPF). Examples of three output files for CPF are given in Appendices VI to X.

2 INPUT AND OUTPUT FILES

2.1 INPUT FILES

To run SEALOAD, the following input files must be available:

1. <filename>.ctr — main input file contains:
   - Principal ship dimensions and hydrostatics
   - physical constants
   - Control indices for computing options
   - Time step data
   - Initial conditions
   - Incident wave information.
2. <filename>.msh — contains the information on node and panels under the waterline.
3. <filename>.data — contains the main ship data, computed hydrostatics and mass distribution. This is an output file from RAD.
4. <filename>.dmp — contains the viscous roll damping coefficients.
5. <filename>.hull — contains the information on nodes and panels on the hull, up to the top of the superstructure.
6. <filename>.otherf — contains the information for computation of resistance, cross flow, thrust, rudder force and maneuvering forces.
7. <filename>.adms — contains the data of added mass, damping and restoring forces. This is an output file from RAD.
8. <filename>.kijf — contains the ship response function due to the radiated waves. This is an output file from RAD.
9. <filename>.kijfx — contains the response function of sea loads acting on a cross-section due to the radiated waves. This is an output file from RAD.

10. <filename>.kijp	contains the response function of pressure on each panel due to the radiated waves. This is an output file from RAD.
11. <filename>.ki7f	contains the ship response function due to the diffracted waves. This is an output file from DIF.
12. <filename>.ki7fx	contains the response function of sea loads acting on a cross-section due to the diffracted waves. This is an output file from DIF.
13. <filename>.ki7p	contains the response function of pressure on each panel due to the diffracted waves. This is an output file from DIF.

where <filename> is a suitably named string up to 25 characters in length.

Note that RAD, DIF, DAMP and SEALOAD share the same input files - <filename>.ctr and <filename>.msh. The format and description of these two files is given in Sections 3 and 4, PART II. Sample input files are presented in Appendices III and IV, PART II.
The files <filename>.data, <filename>.adms, <filename>.kijf, <filename>.kijfx, <filename>.kijp, <filename>.ki7f, <filename>.ki7fx, <filename>.ki7p, are the output files from RAD and DIF. Their formats and descriptions are presented in PART II and PART III. <filename>.damp is the output from DAMP. Its format and descriptions are in PART IV.

The user must provide the input files - <filename>.otherf and <filename>.hull. The format and description of these two files is presented in Section 3 and 4. Examples are given in Appendices VI and VII.

The organization of input/output files for SEALOAD is shown in Figure 2.1.

2.2 OUTPUT FILES

With a correct input and a successful execution of the program, the following output files are produced:

1.	<filename>.wave	Contains incident waves for each time step at the origin of either the space-fixed coordinate system or the steady-moving coordinate system.
2.	<filename>.wspct	Contains theoretical wave spectrum.
3.	<filename>.wspcn	Contains estimated wave spectrum.
4.	<filename>.chkf	Contains a display of information on the components of the exciting forces.
5.	<filename>.motion	Contains displacements of ship motions for each time step.
6.	<filename>.vel	Contains velocities of ship motions for each time step.
7.	<filename>.acc	Contains accelerations of ship motions for each time step.
8.	<filename>.fx	Contains sea loads acting on the given cross section for each time step.
9.	<filename>.pres	Contains pressure distributions on the panels under the waterline for each time step.

The format and description of the output files is given in Section 5 and examples of three output files are presented in Appendices VIII to X.

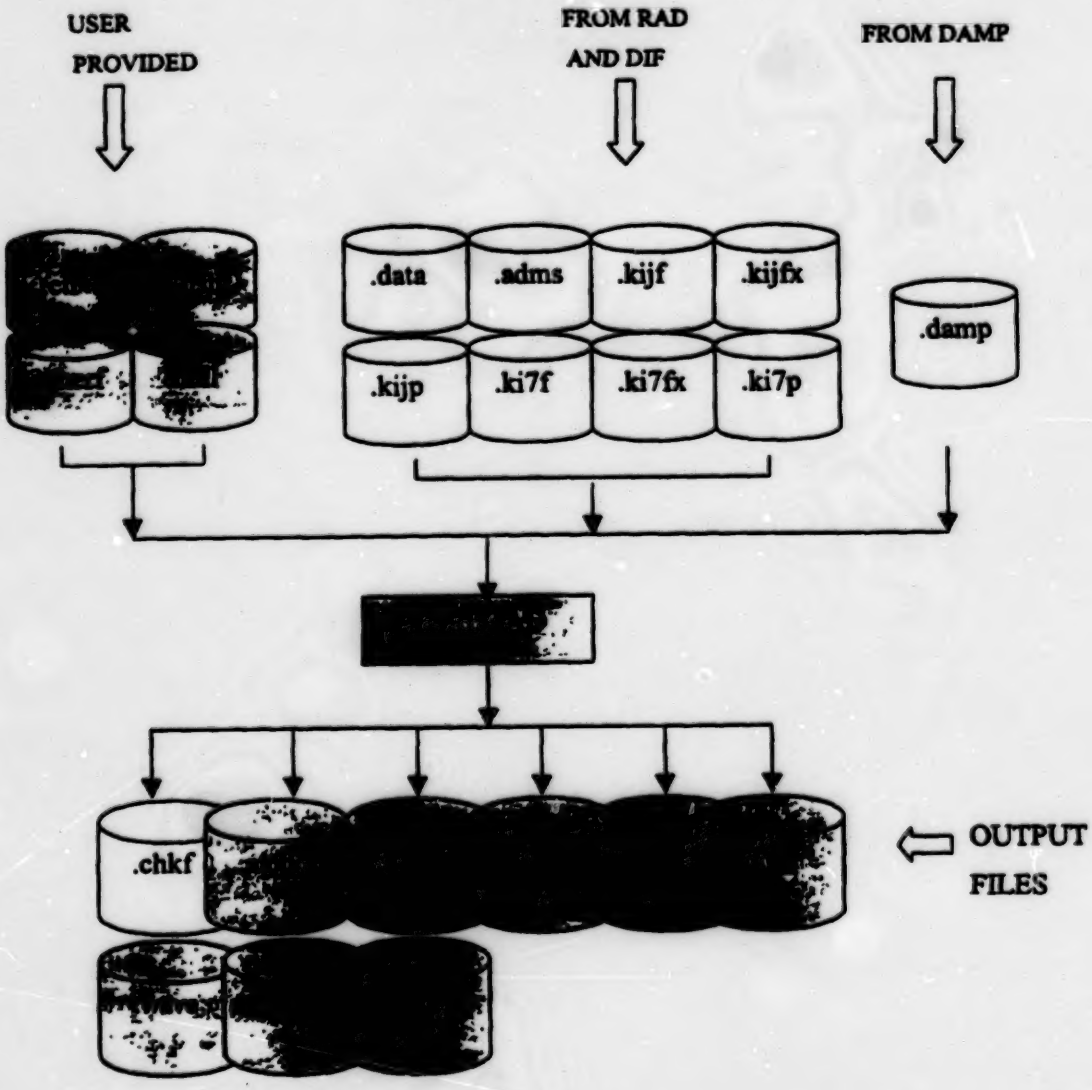

Figure 2.1 Organization of input/output files for SEALOAD

3 FORMAT OF INPUT FILES

The following are the format of the input files **<filename>.otherf** and **<filename>.hull**. Definitions of the records in these files are given in Section 4. Comment lines can be introduced by making '#' as the first character of the line. The program does not differentiate lower or upper case characters.

3.1 FORMAT OF <FILENAME>.OTHERF

```
# Options for the computation of resistance, cross-flow drag, propeller thrust, rudder
# force, maneuvering force and slamming force.

&inputforcecontrol
resisctr
crossctr
propctr
maneuctr
rudderctr
/

# Resistance data from experiments

&resisdata
numdata
uspeed(1),     uspeed(2),     ...,     uspeed(numdata-1),     uspeed(numdata)
resistance(1), resistance(2), ...,     resistance(numdata-1), resistance(numdata)
/end{resisdata}

# Measured cross flow drag

&crossflow
```

numcross
crossspeed(1), crossspeed(2), ..., crossspeed(numcross)
crossdrag(1), crossdrag(2), ..., crossdrag(numcross)
/end{crossflow}

Sectional geometry information for estimation of cross flow drag

&crosssection
nsection
xcross(1), xcross(2), ..., xcross(nsection-1), xcross(nsection)
zcross(1), zcross(2), ..., zcross(nsection-1), zcross(nsection)
/end{crosssection}

Wake fraction and thrust deduction fraction

&wake
wakef
thrustdf
/end{wake}

Propeller geometry data

&propeller
diameter
rpm
/end{propeller}

Measured thrust and torque coefficients of propeller: K_T - K_Q -J chart

&prophyd
numkt

kt(1), kt(2), ..., kt(numkt-1), kt(numkt)
kq(1), kq(2), ..., kq(numkt-1), kq(numkt)
jt(1), jt(2), ..., jt(numkt-1), jt(numkt)
/end{prophyd}

Maneuvering coefficients

&maneuver
ycoeff(1), ycoeff(2), ..., ycoeff(5), ycoeff(6)
ncoeff(1), ncoeff(2), ..., ncoeff(5), ncoeff(6)
/end{maneuver}

Rudder geometry data

&ruddergeo
gap
rudwidth
aspectratio
xrudc
zrudc
rudarea
/end{ruddergeo}

Data for autopilot

&autopilot
bias
gainangle
gainrate
threshold
rudlim

3.2 FORMAT OF <FILENAME>.HULL

nodenum, npanel

1, x(1), y(1), z(1)

2, x(2), y(2), z(2)

…, …, …, …

nodenum-1, x(nodenum-1), y(nodenum-1), z(nodenum-1)

nodenum, x(nodenum), y(nodenum), z(nodenum)

1, nodes(1,1), nodes(2,1), nodes(3,1), nodes(4,1)

2, nodes(1,2), nodes(2,2), nodes(3,2), nodes(4,2)

…, …, …, …, …

npanel-1, nodes(1,npanel-1), nodes(2,npanel-1), nodes(3,npanel-1), nodes(4,npanel-1)

npanel, nodes(1,npanel), nodes(2,npanel), nodes(3,npanel), nodes(4,npanel)

4 DESCRIPTION OF INPUT FILES

4.1 DESCRIPTION OF <FILENAME>.OTHERF

4.1.1 INPUTFORCECONTROLS RECORDS

Resisctr - options for the resistance computation. Appendix I presents the theoretical background for the resistance computation.
= 0, resistance won't be computed in SEALOAD
= 1, resistance will be computed from the input test data
= 2, resistance will be computed from empirical formulae

crossctr - options for the cross-flow drag computation. Appendix II gives the theoretical background.
= 0, cross-flow drag won't be computed in SEALOAD
= 1, cross-flow drag will be computed from the input test data
= 2, cross-flow drag will be computed from empirical formulae

propctr - options for the propeller thrust computation. Appendix III gives the theoretical background.
= 0, propeller thrust is equal to the calm water resistance at the input forward speed
= 1, propeller thrust will be computed from the K_T-K_Q-J chart input by the user

maneuctr - options for the maneuvering force computation. Appendix IV presents the theoretical background.
= 0, maneuvering force won't be computed
= 1, maneuvering force will be computed from the hydrodynamic derivatives provided by the user
= 2, the maneuvering force will be computed from the hydrodynamic derivatives obtained from empirical formulae

rudderctr - options for the rudder force computation. The theoretical background is given in Appendix V.

= 0, rudder force won't be computed

= 1, rudder force will be computed from the rudder geometry provided by the user

slamctr - options for the slamming force computation, theoretical background is presented in Appendix VI.

= 0, slamming forces won't be computed

= 1, slamming forces will be computed.

The above record must not be omitted.

4.1.2 RESISDATA RECORD

This record contains the calm water resistance from experiments. The computational technique is presented in Appendix I.

If resisctr ≠ 1, this record can be omitted.

numdata - number of test data, 50 maximum.

uspeed - forward speeds, *m/s*. Uspeed(1), uspeed(2), ..., uspeed(numdata).

resistance - calm water resistance, *Newton*, corresponding to the given forward speeds. resistance(1), resistance(2), ..., resistance(numdata).

4.1.3 CROSSFLOW RECORDS

This record contains the measured cross-flow drag, referring to Appendix II for the cross-flow drag computation.

If crossctr ≠ 1, this record can be omitted.

numcross - number of test data, 50 maximum.

crossspeed - transverse speeds of flow, *m / s* . crossspeed(1), crossspeed(2), ..., crossspeed(numcross).

crossdrag - measured cross-flow drag, *Newton,* corresponding to transverse speeds, crossspeed. crossdrag(1), crossdrag(2), ..., crossdrag(numcross).

4.1.4 CROSSSECTION RECORD

This record contains the sectional geometry for cross-flow drag computation (see Appendix II for the theoretical background).

If crossctr ≠ 2, this record can be omitted.

nsection - number of cross sections (50, maximum). It can be equal to the number of stations.

xcross - x-coordinate of a cross-section, *meter* (see Figure 4.1). All sections must be equally spaced.

zcross - draft of at the corresponding cross-section, *meter*. (see Figure 4.1)

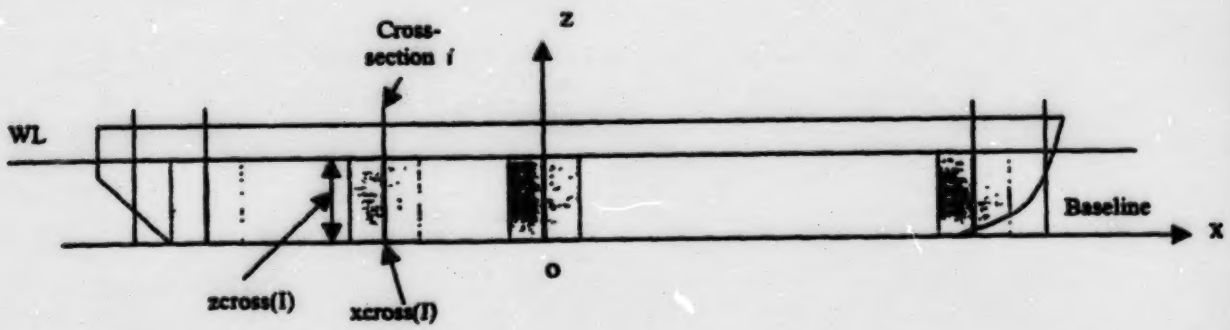

Figure 4.1 Sectional geometry for cross-flow drag computation

4.1.5 WAKE RECORD

If propctr ≠ 1, this record can be omitted.

wakef - wake fraction
thrustdf - thrust deduction fraction

4.1.6 PROPERLLER RECORDS

If propctr ≠ 1, this record can be omitted.

diameter - diameter of the propeller, *meter*.
rpm - revolutions per minute (RPM) of the propeller

4.1.7 PROPHYD RECORD

If propctr ≠ 1, this record can be omitted.

numkt - number of test data points (50, maximum)
kt - thrust coefficients. kt(1), kt(2), ..., kt(numkt).
kq - torque coefficients. kq(1), kq(2), ..., kq(numkt).
jt - advancing ratio. jt(1), jt(2), ..., jt(numkt).

4.1.8 MANEUVER RECORDS

If maneuctr ≠ 1, this record can be omitted.

ycoeff - hydrodynamic derivatives for maneuvering force, ycoeff(1), ycoeff(2), ..., ycoeff(5), ycoeff(6). Definitions of derivative coefficients are presented in Appendix IV.

ncoeff - hydrodynamic derivatives for maneuvering moment.
Definitions of these derivatives are given in Appendix IV.

4.1.9 RUDDERGEO RECORDS

These records contain information of rudder geometry for computing rudder forces. The theoretical background is presented in Appendix V. The geometry of the rudder is shown in Figure 4.2.

If rudderctr ≠ 1, these records can be omitted.

gap - distance, *meter*, from the leading edge of rudder to the hull.
rudwidth - rudder width, *meter*.
aspectratio - aspect ratio of the rudder defined as the ratio of rudder height to rudder width.
xrudc - horizontal distance, *meter*, from the center of gravity of ship to the center of pressure of rudder.
zrudc - vertical distance, *meter*, from the center of gravity of ship to the center of pressure of rudder.
rudarea - rudder planform area, $meter^2$.

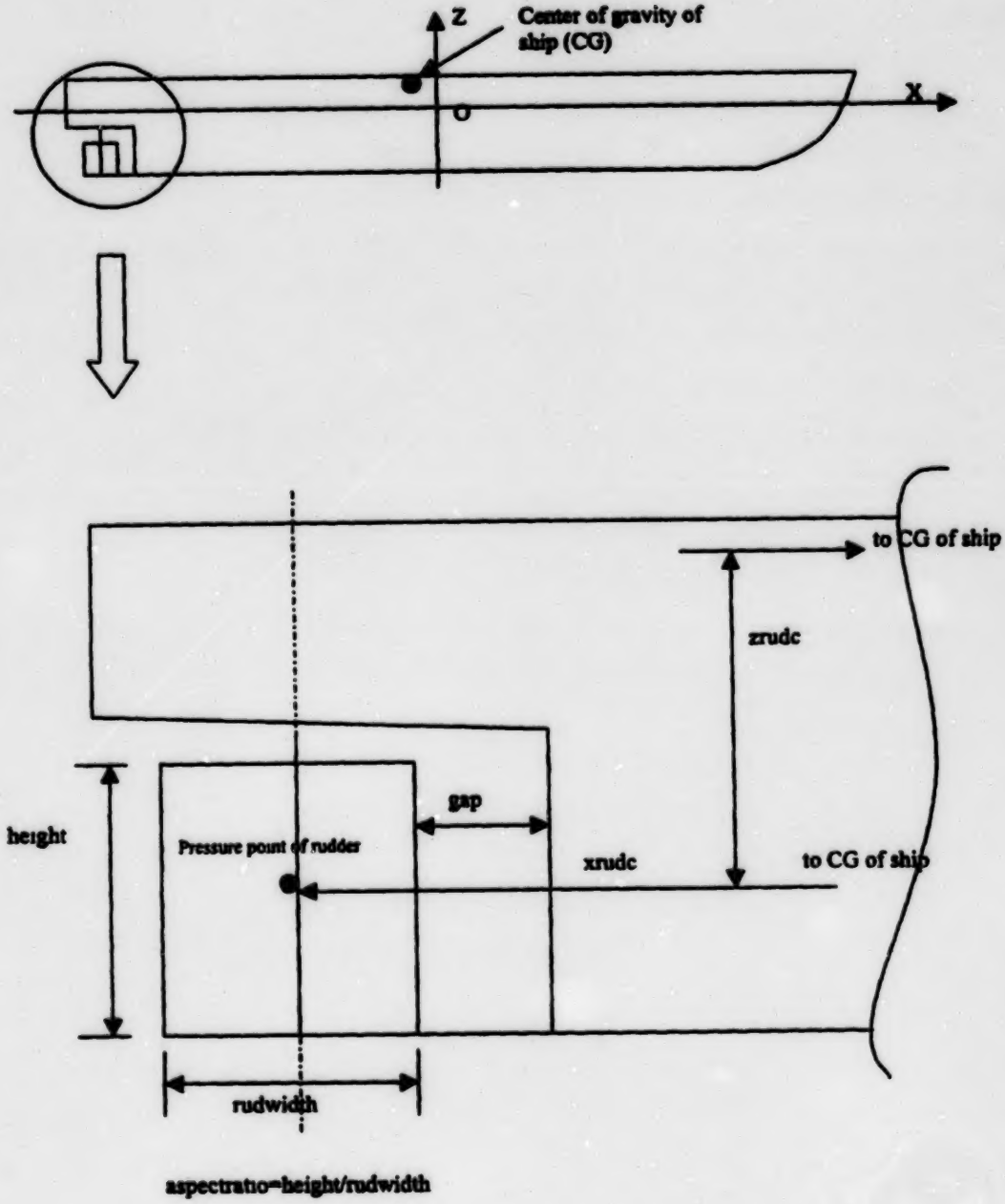

Figure 4.2 Rudder geometry

4.1.10 AUTOPILOT RECORDS

These records contain information for auto-pilot controls. The theoretical background is presented in Appendix V.

If rudderctr ≠ 1, the following records can be omitted.

bias	- constant bias angle of rudder, *degree*.
gainangle	- gain of yaw angle
gainrate	- gain of yaw rate
threshold	- threshold angle of yaw, *degree*, beyond which the rudder will be activated.
rudlim	- maximum rudder angle, *degree*.

4.2 DESCRIPTION OF <FILENAME>.HULL

The hull surface on the port side up to the superstructure is discretized into a number of quadrilateral panels for nonlinear Froude-Krylov force computation. This file contains the information on nodes and panel connectivity.

RECORD 1 – NODENUM, NPANEL

NODENUM	- number of nodes on the port side of hull (10000 maximum)
NPANEL	- number of panels on the port side of hull (10000 maximum)

RECORD 2 – NO(I), X(I), Y(I), Z(I), I=1, 2, ..., NODENUM

NO(I)	- number identifying the *i*th node point
X(I), Y(I), Z(I)	- coordinates of the *i*th node point. The coordinates are with respect to a right-handed coordinate system with the origin at the intersection of the centerline and the design waterline the midship section (see Figure 4.1, PART II).

RECORD 3 – NO(I), PANEL(1,I), PANEL(2,I), PANEL(3,I), PANEL(4,I), I = 1, 2, ..., NPANEL

NO(I)	- number identifying the *i*th panel.
PANEL(1,I)	- first node of the *i*th panel.
PANEL(2,I)	- second node of the *i*th panel.
PANEL(3,I)	- third node of the *i*th panel.
PANEL(4,I)	- fourth node of the *i*th panel.

The input nodes in each panel must be entered in a sequence such that the normal direction of the panel points to the inside of the hull as if the panel is viewed from inside of the hull (see Figure 4.4, PART II).

5 DESCRIPTION OF OUTPUT FILES

The following is a brief description of the records in the output files <filename>.wave, <filename>.wspct, <filename>.spcn, <filename>.chkf, <filename>.motion, <filename>.vel, <filename>.acc, <filename>.fx, <filename>.pres.

5.1 <FILENAME>.WAVE

This file contains the incident waves at each time step. If **outwave=1**, the output incident wave elevations are at the origin of the space-fixed coordinate system; If **outwave=0**, the output incident waves are at the origin of the steady-moving coordinate system. The format of this file is as follows:

1	t(1),	elevation(1)
2	t(2),	elevation(2)
	...,	...
n-1	t(n-1),	elevation(n-1)
n	t(n),	elevation(n)

where n is the total number of time steps. An example of this file is shown in Appendix II.

5.3 <FILENAME>.WSPCT

This file contains the theoretical wave spectrum of irregular waves (if **wavetype ≠ 0 or 6**). The format is as follows:

1	Frequency(1) (*Hz*),	spectrum(1) (m^2/Hz)
2	Frequency(2),	spectrum(2)
...	...,	...

n-1	Frequency(n-1),	spectrum(n-1)
n	Frequency(n),	spectrum(n)

where n is the number of total frequencies.

5.4 <FILENAME>.WSPCN

This file contains the estimated wave spectrum of irregular waves (if wavetype≠ 0 or 6) generated by the numerical method. The format is as follows:

1	Frequency(1) (*Hz*),	spectrum(1) (m^2/Hz)
2	Frequency(2),	spectrum(2)
...	...,	...
n-1	Frequency(n-1),	spectrum(n-1)
n	Frequency(n),	spectrum(n)

where n is the number of total frequencies.

5.5 <FILENAME>.CHKF RECORDS

This file contains the exciting force components at each 10 time steps as follows:

- Total exciting forces, Ftot(6,n), where n is the total number of time steps.
- Radiation force, Frad(6,n)
- Diffraction force, Fdif(6,n)
- Froude-Krylov force, FK(6,n)
- Restoring force, Fres(6,n)
- Damping force, Fdmp(6,n)
- Slamming force, Fslam(6,n)

In general, the output forces are nondimensionalized as follows:

$F_i (i = 1,2,3)$: $F_i / \rho g L B H$

$F_i (i = 4,5,6)$: $F_i / \rho g L^2 B H$

where ρ is the density of water; g is the acceleration due to gravity; L is the characteristic length of the ship ($= L_{BP}$, length between perpendiculars); B is the beam of the ship; and H is the wave height. $F_i (i = 1,2,3)$ are the shear forces in x, y, and z directions. $F_i (i = 4,5,6)$ are the bending moments about the x, y, and z-axis, respectively.

The format of this file is given as below:

Record	Description			
1.	Time (step=1)			
	Ftot(1,1),	Ftot(2,1),	...,	Ftot(6,1),
	Frad(1,1),	Frad(2,1),	...,	Frad(6,1),
	Fdif(1,1),	Fdif(2,1),	...,	Frad(6,1),
	FK(1,1),	FK(2,1),	...,	FK(6,1),
	Fres(1,1),	Fres(2,1),	...,	Fres(6,1),
	Fdmp(1,1),	Fdmp(2,1),	...,	Fdmp(6,1),
	Fslam(1,1),	Fslam(2,1),	...,	Fslam(6,1)
2.	Time (step=2)			
	Ftot(1,2),	Ftot(2,2),	...,	Ftot(6,2),
	Frad(1,2),	Frad(2,2),	...,	Frad(6,2),
	Fdif(1,2),	Fdif(2,2),	...,	Frad(6,2),
	FK(1,2),	FK(2,2),	...,	FK(6,2),
	Fres(1,2),	Fres(2,2),	...,	Fres(6,2),
	Fdmp(1,2),	Fdmp(2,2),	...,	Fdmp(6,2),
	Fslam(1,2),	Fslam(2,2),	...,	Fslam(6,2)

n-1	Time (step=n-1)			
	Ftot(1,n-1),	Ftot(2,n-1),	...,	Ftot(6,n-1),
	Frad(1,n-1),	Frad(2,n-1),	...,	Frad(6,n-1),
	Fdif(1,n-1),	Fdif(2,n-1),	...,	Frad(6,n-1),
	FK(1,n-1),	FK(2,n-1),	...,	FK(6,n-1),
	Fres(1,n-1),	Fres(2,n-1),	...,	Fres(6,n-1),
	Fdmp(1,n-1),	Fdmp(2,n-1),	...,	Fdmp(6,n-1),
	Fslam(1,n-1),	Fslam(2,n-1),	...,	Fslam(6,n-1)
n	Time (step=n)			
	Ftot(1,n),	Ftot(2,n),	...,	Ftot(6,n),
	Frad(1,n),	Frad(2,n),	...,	Frad(6,n),
	Fdif(1,n),	Fdif(2,n),	...,	Frad(6,n),
	FK(1,n),	FK(2,n),	...,	FK(6,n),
	Fres(1,n),	Fres(2,n),	...,	Fres(6,n),
	Fdmp(1,n),	Fdmp(2,n),	...,	Fdmp(6,n),
	Fslam(1,n),	Fslam(2,n),	...,	Fslam(6,n)

Where n is the total number of time steps.

5.6 <FILENAME>.MOTION

This file contains ship motions at each time step. The output ship motions are nondimensionalized as follows:

$$X_i (i = 1,2,3): \qquad X_i / A$$
$$X_i (i = 4,5,6): \qquad X_i / kA$$

where $X_i (i = 1,2,3,4,5,6)$ are the displacements of ship motions corresponding to surge, sway, heave, roll, pitch and yaw, respectively; The symbol, A, denotes the wave amplitude and k is the wave number.

Time	Displacements of ship motions in six modes at each time step					
t(1)	$X_1(1)$	$X_2(1)$	$X_3(1)$	$X_4(1)$	$X_5(1)$	$X_6(1)$
t(2)	$X_1(2)$	$X_2(2)$	$X_3(2)$	$X_4(2)$	$X_5(2)$	$X_6(2)$
	...	...	...	...	...	...
t(n)	$X_1(n)$	$X_2(n)$	$X_3(n)$	$X_4(n)$	$X_5(n)$	$X_6(n)$

where n is the total number of time step.

5.7 <FILENAME>.VEL

This file contains the velocities of ship motions at each time step.

Time	Velocities of ship motions in six modes at each time step					
t(1)	vel(1,1)	vel(2,1)	vel(3,1)	vel(4,1)	vel(5,1)	vel(6,1)
t(2)	vel(1,2)	vel(2,2)	vel(3,2)	vel(4,2)	vel(5,2)	vel(6,2)
...	...	...	...	...	...	...
t(n)	vel(1,n)	vel(2,n)	vel(3,n)	vel(4,n)	vel(5,n)	vel(6,n)

where n is the total number of time step.

5.8 <FILENAME>.ACC

This file contains the acceleration of ship motions at each time step

Time	Accelerations of ship motions in six modes at each time step					
t(1)	acc(1,1)	acc(2,1)	acc(3,1)	acc(4,1)	acc(5,1)	acc(6,1)
t(2)	acc(1,2)	acc(2,2)	acc(3,2)	acc(4,2)	acc(5,2)	acc(6,2)
...	...	...	...	...	...	...
t(n)	acc(1,n)	acc(2,n)	acc(3,n)	acc(4,n)	acc(5,n)	acc(6,n)

where n is the total number of time step.

5.9 <FILENAME>.FX

This file contains the sea loads acting on a cross-section at each time step. If sealoadctr=0, the file won't be produced. The output sea loads are nondimensionalized as described in Section 5.1.

Time	Sea loads in six modes at each time step					
t(1)	fx(1,1)	fx(2,1)	fx(3,1)	fx(4,1)	fx(5,1)	fx(6,1)
t(2)	fx(1,2)	fx(2,2)	fx(3,2)	fx(4,2)	fx(5,2)	fx(6,2)
...	...	...	...	...	...	...
t(n)	fx(1,n)	fx(2,n)	fx(3,n)	fx(4,n)	fx(5,n)	fx(6,n)

where n is the total number of time step.

5.10 <FILENAME>.PRES

This file contains the pressure distribution on hull at each time step. If Presctr=0, this file won't be produced.

The pressure is nondimensionalized as follows:

$$P: \quad P / \rho g A$$

Where P, ρ, g and A denote the pressure, water density, acceleration due to gravity and wave amplitude, respectively.

Time	Pressure distributions over panels at each time step				
t(1)	pres(1,1)	pres(2,1)	...	pres(npanel-1,1)	pres(npanel,1)
t(2)	pres(1,2)	pres(2,2)	...	pres(npanel-1,2)	pres(npanel,2)
...	...	...	...	...	...
t(n)	pres(1,n)	pres(2,n)	...	pres(npanel-1,n)	pres(npanel,n)

where n is the total number of time step and npanel is the total number of panels under waterline.

REFERENCES

[1] Holtrop, J. and Mennen, G., "An approximate power prediction method", International Shipbuilding Progress, Vol. 29, No. 335, July 1982.

[2] Kijima, K., Katsuno, T., Nakiri, Y. and Furukawa, Y., "On the maneuvering performance of a ship with the parameter of loading condition", Journal of the Society of Naval Architects of Japan, Vol. 168, pp.141-148, 1990.

APPENDIX I RESISTANCE COMPUTATION

The resistance is important to surge, sway and yaw in the time-domain simulation. If the resistance model test data are available, the resistance can be interpolated at the prescribed speed. If there are no test data available, empirical formulae, given by Holtrop and Mennen (1982) [1], can be used as resistance estimation for a generic hull form.

For a specific hull form, the user can input the empirical formulae by changing the code.

APPENDIX II CROSS-FLOW DRAG COMPUTATION

The cross-flow drag affects the surge, sway and yaw motions. If there is a measured cross-flow drag available, the cross-flow drag will be interpolated at the relative velocity between the hull and the water particle of the local cross-flow.

The cross-flow drag and moment can also be estimated from the cross-section geometry as follows:

$$F_2^{cross} = -\frac{1}{2}\rho \int_0^L C_d(x)T(x)v_2(x,t)|v_2(x,t)|dx \qquad \text{(II-1)}$$

$$F_6^{cross} = -\frac{1}{2}\rho \int_0^L xC_d(x)T(x)v_2(x,t)|v_2(x,t)|dx \qquad \text{(II-2)}$$

where $C_d(x)$ is the sectional cross-flow coefficient (=1.5); $T(x)$ is the local draft of the ship at section x; L is the ship's length between perpendiculars; and $v_2(x,t)$ is the transverse relative velocity between the hull and the water particles of the local cross-flow.

APPENDIX III PROPELLER THRUST COMPUTATION

The thrust and torque of the propeller can be estimated from the available $K_T - K_Q - J$ charts of a standard propeller series as follows:

$$F_1^{prop} = (1-t_p)\rho n_p^2 D_p^4 K_T(J) \quad \text{(III-1)}$$

$$F_4^{prop} = \rho n_p^2 D_p^5 K_Q(J) \quad \text{(III-2)}$$

$$J = \frac{U(1-w)}{n_p D_p} \quad \text{(III-3)}$$

where t_p and w are the thrust deduction fraction and wake fraction, respectively; n_p is the number of revolutions per second of the propeller; D_p is the propeller diameter; U is the forward speed of the ship; J is the advancing ratio; K_T and K_Q are the thrust coefficient and the torque coefficient, respectively.

APPENDIX IV MANEUVERING FORCE COMPUTATION

The following nonlinear lateral force and turning moment are adopted in the seakeeping simulation [2]:

$$F_2^{maneu}(t) = \frac{1}{2}\rho LT\overline{U}^2(Y_\beta\beta' + Y_\gamma\gamma' + Y_{\beta\beta}|\beta'|\beta' + Y_{\gamma\gamma}|\gamma'|\gamma' + (Y_{\beta\beta\gamma}\beta' + Y_{\beta\gamma\gamma})\beta'\gamma') \quad \text{(IV-1)}$$

$$F_6^{maneu}(t) = \frac{1}{2}\rho L^2T\overline{U}^2(N_\beta\beta' + N_\gamma\gamma' + N_{\beta\beta}|\beta'|\beta' + N_{\gamma\gamma}|\gamma'|\gamma' + (N_{\beta\beta\gamma}\beta' + N_{\beta\gamma\gamma})\beta'\gamma') \quad \text{(IV-2)}$$

where L is the ship length; T is the ship draft; $\beta' = -u_2/\overline{U}$ and $\gamma' = u_6 L/\overline{U}$; $\overline{U}$ is the instantaneous forward velocity (i.e., the forward speed of ship plus the surge velocity); u_2 and u_6 are the instantaneous sway and yaw velocities, respectively. The hydrodynamic derivatives $Y's$ and $N's$ can be determined from empirical formulae or using test data.

In SEALOAD, we define

ycoeff(1) = Y_β	ncoeff(1) = N_β
ycoeff(2) = Y_γ	ncoeff(2) = N_γ
ycoeff(3) = $Y_{\beta\beta}$	ncoeff(3) = $N_{\beta\beta}$
ycoeff(4) = $Y_{\gamma\gamma}$	ncoeff(4) = $N_{\gamma\gamma}$
ycoeff(5) = $Y_{\beta\beta\gamma}$	ncoeff(5) = $N_{\beta\beta\gamma}$
ycoeff(6) = $Y_{\beta\gamma\gamma}$	ncoeff(6) = $N_{\beta\gamma\gamma}$

These coefficients can be estimated as follows [2] if no test data are available:

$$Y_\beta = \frac{1}{2}\pi k + 1.4C_b B/L \quad \text{(IV-3)}$$

$$Y_r = -1.5C_b B/L + m' + m'_x \quad \text{(IV-4)}$$

$$Y_{\beta\beta} = 2.5T(1-C_b)/B + 0.5 \quad \text{(IV-5)}$$

$$Y_{rr} = 0.343TC_b/B - 0.07 \quad \text{(IV-6)}$$

$$Y_{\beta rr} = 5.95T(1-C_b)/B \quad \text{(IV-7)}$$

$$Y_{\beta\beta r} = 1.5TC_b/B - 0.65 \quad \text{(IV-8)}$$

$$N_\beta = k \quad \text{(IV-9)}$$

$$N_r = -0.54k + k^2 \quad \text{(IV-10)}$$

$$N_{\beta\beta} = -0.96T(1-C_b)/B + 0.066 \quad \text{(IV-11)}$$

$$N_{rr} = 0.5C_b B/L - 0.09 \quad \text{(IV-12)}$$

$$N_{\beta rr} = -(0.5TC_b/B - 0.05) \quad \text{(IV-13)}$$

$$N_{\beta\beta r} = -[57.5(C_b B/L)^2 - 18.4C_b B/L + 1.6] \quad \text{(IV-14)}$$

where

$$k = 2T/L \quad \text{(IV-15)}$$

$$m' = m/(0.5\rho L^2 T) \quad \text{(IV-16)}$$

$$m'_x = 2.7m^{5/3}/L^2/(0.5\rho L^2 T) \quad \text{(IV-17)}$$

L, B, T, and C_b are the ship length, beam, draft and block coefficient, respectively. m and m_x are the ship's mass and the added-mass in the x-direction, respectively.

APPENDIX V RUDDER FORCE COMPUTATION

According to [2], the normal force acting on the rudder can be estimated by:

$$F_N = -\frac{1}{2}\rho\frac{6.13\lambda}{\lambda+2.25}A_R V_R^2 \sin\alpha_e \qquad \text{(V-1)}$$

where λ is the aspect ratio of the rudder; A_R is the rudder planform area; V_R is the velocity of a water particle relative to the rudder; ρ is the water density and α_e is the effective rudder angle:

$$\alpha_e = \alpha + \tan^{-1}\left(\frac{u_2 - d_z u_6 + d_x u_4}{(1-w)U + u_1}\right) \qquad \text{(V-2)}$$

where α is the rudder angle defined as positive angle when it is turned to the port side; U is the ship forward speed; w is the wake fraction; d_x and d_z are the horizontal and vertical distances between the rudder's center of pressure and the center of gravity of ship, respectively; $u_i (i=1,2,3,4,5,6)$ denote the velocities of ship motions. The components of rudder force can be obtained as follows:

$$F_1^{RUD} = -|F_N|\sin\alpha \qquad \text{(V-3)}$$

$$F_2^{RUD} = F_N\cos\alpha \qquad \text{(V-4)}$$

$$F_4^{RUD} = d_z F_N\cos\alpha \qquad \text{(V-5)}$$

$$F_5^{RUD} = -d_x F_N\cos\alpha \qquad \text{(V-6)}$$

For the course-keeping purpose, the following auto-pilot can be used:

$$\alpha(t) = \begin{cases} \alpha_1^r s_6 + \alpha_2^r u_6 & \text{if } s_6 > \alpha_0 \\ 0 & \text{if } s_6 \le \alpha_0 \end{cases} \qquad \text{(V-7)}$$

where α_1^r and α_2^r denote the yaw gain and the yaw rate gain, respectively; s_6 is the yaw angle; and α_0 is the threshold value of yaw beyond which the rudder is activated.

APPENDIX VI CPF.OTHERF

```
# this file deals with the rudder force, manuvering force,
# cross flow force, proplusion force and resistance.


# control data for the input forces

&inputforcecontrol
resisctr  = 0
crossctr  = 0
propctr   = 0
maneuctr   = 0
rudderctr = 0
/

# resistance data

&resisdata
numdata    =
uspeed, resistance =
/endresisdata

# cross flow

&crossflow
numcross   =
crossspeed =
crossdrag  =
/endcrossflow

# cross-sectional geometry

&crosssection
nsection=22
xcross =  -62.2000
       -61.7000
       -59.3750
       -56.2500
       -50.0000
       -43.7500
       -37 5000
       -31.2500
       -25.0000
       -18.7500
       -12.5000
        -6.2500
         0.0000
         6.2500
        12.5000
        18.7500
        25.0000
        31.2500
        37.5000
        43.7500
       -62.2000
       -61.7000
       -59.3750
       -56.2500
       -50.0000
       -43.7500
       -37.5000
       -31.2500
       -25.0000
       -18.7500
       -12.5000
        -6.2500
```

```
          0.0000
          6.2500
         12.5000
         18.7500
         25.0000
         31.2500
         37.5000
         43.7500
         50.0000
         62.7500
zcross=
          0.0000
          0.9375
          1.0940
          1.3300
          2.0300
          3.1200
          4.4830
          5.0000
          5.0000
          5.0000
          5.0000
          5.0000
          5.0000
          5.0000
          5.0000
          5.0000
          5.0000
          5.0000
          5.0000
          5.0000
          0.0000
          0.9375
          1.0940
          1.3300
          2.0300
          3.1200
          4.4830
          5.0000
          5.0000
          5.0000
          5.0000
          5.0000
          5.0000
          5.0000
          5.0000
          5.0000
          5.0000
          5.0000
          5.0000
          5.0000
          5.0000
          5.0000
          0.0000
/endcrosssection

$ wake coefficients

&wake
wakef    =
thrustdf =
/endwake

$ propeller geometry

&propeller
diamater =
rpm      =
/endpropeller

$ propeller hydrodynamic coefficients kt,kq
```

```
&prophyd
numkt  =
kt     =
kq     =
jt     =
/endprophyd

# manuvering coefficients

&manuver
ycoeff =
ncoeff =
/endmanver

# rudder geometry

&ruddergeo
gap        = 5.0
rudwidth   = 3.415
aspectratio= 1.552
xrudc      = 59.291
zrudc      = 4.515
rudarea    = 19.00
/endruddergeo

# Autopilot information

&autopilot
bias      = 0.0
gainangle = 1.0
gainrate  = 0.0
threshold = 0.0
rudlim    = 35.0
/endautopilot
```

APPENDIX VII CPF.HULL

```
4816  4527
    1    60.17500      0.00000     -2.96049
    2    60.17500      0.00000     -2.94049
    3    60.17500      0.00000     -2.94049
    4    60.17500      0.00000     -2.94049
    5    60.17502      0.00000     -2.94046
  ...    ...           ...          ...

 4814   -64.37111      0.00000      4.72099
 4815   -64.51389      0.00000      5.07679
 4816   -64.74000      0.00000      5.66000
    1      1      2     33     32
    2      2      3     34     33
    3      3      4     35     34
    4      4      5     36     35
    5      5      6     37     36
   ..     ..     ..     ..     ..
 4524   4793   4794   4813   4812
 4525   4794   4795   4814   4813
 4526   4795   4796   4815   4814
 4527   4796   4797   4816   4815
```

APPENDIX VIII CPF.WAVE

0.0000	0.0000
0.0200	0.0027
0.0400	0.0054
0.0600	0.0081
0.0800	0.0108
0.1000	0.0135
0.1200	0.0161
0.1400	0.0187
0.1600	0.0213
0.1800	0.0239
0.2000	0.0265
0.2200	0.0290
0.2400	0.0315
0.2600	0.0340
0.2800	0.0364
0.3000	0.0388
..	...

APPENDIX IX CPF.MOTION

0.4000E-01	0.4680E-05	-0.1086E-09	-0.3303E-05	0.1765E-09	0.1019E-04	0.8613E-10
0.6000E-01	0.1390E-04	0.2504E-09	-0.1027E-04	0.5847E-09	0.3015E-04	-0.6013E-10
0.8000E-01	0.2753E-04	0.4617E-09	-0.2127E-04	0.3220E-09	0.5946E-04	0.9023E-12
0.1000E+00	0.4543E-04	0.1809E-09	-0.3667E-04	0.3370E-09	0.9771E-04	0.2649E-09
0.1200E+00	0.6745E-04	-0.1220E-09	-0.5686E-04	-0.1432E-09	0.1445E-03	0.3663E-09
0.1400E+00	0.9346E-04	-0.5421E-09	-0.8221E-04	0.2525E-09	0.1993E-03	0.6217E-05
0.1600E+00	0.1233E-03	-0.8130E-05	-0.1131E-03	0.1012E-08	0.2619E-03	0.4348E-09
0.1800E+00	0.1569E-03	-0.1161E-08	-0.1499E-03	0.2092E-08	0.3317E-03	0.7410E-10
0.2000E+00	0.1940E-03	-0.1526E-08	-0.1931E-03	0.2936E-08	0.4085E-03	-0.3162E-09
.	.	-	-	-	-	-

APPENDIX X CPF.FX

```
0.4000E-01 -0.5026E+01 -0.1298E-04 -0.2842E+01  0.3748E-05  0.2619E+02 -0.3595E-04
0.6000E-01 -0.5019E+01 -0.1160E-04 -0.2870E+01  0.7036E-06  0.2627E+02 -0.3969E-04
0.8000E-01 -0.5013E+01  0.1452E-04 -0.2898E+01 -0.2690E-05  0.2636E+02  0.4119E-04
0.1000E+00 -0.5007E+01 -0.8319E-05 -0.2926E+01  0.5745E-08  0.2644E+02  0.7857E-04
0.1200E+00 -0.5000E+01  0.8440E-06 -0.2954E+01 -0.2448E-07  0.2653E+02 -0.3765E-04
0.1400E+00 -0.4994E+01 -0.3701E-05 -0.2982E+01  0.6278E-06  0.2661E+02  0.2711E-04
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The 3D time-domain computer program SEALOADS version 1.0 calculates the nonlinear response of a ship in severe waves in the time-domain. The output includes ship motions, hydrodynamic pressure distribution, and hull-girder loads. The program written in FORTRAN consists of four independent sub-programs: RAD to compute the response function due to radiated waves; DIF to compute the response function due to diffracted waves; DAMP to compute the roll damping coefficients; and SEALOAD, the main program to compute the ship motions, pressures, and hull-girder loads. This manual describes the installation and operation of SEALOADS version 1.0 on a FreeBSD UNIX system. The structures of input and output data files are described, and example files are illustrated.

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